Engineering Library

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MAY 8 1929

The Engineer.

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VOL. CXLVII.—No. 3824] LONDON: FRIDAY EVENING, APRIL 26, 1929 [PRICE { WITH SUPPLEMENT } ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director-General, India Store Department, Belvedere-road, Lambeth, London, S.E. 1, invites TENDERS for :—

SCHEDULE 1.—592 PAIRS of DISC WHEELS and AXLES, Metre Gauge.
SCHEDULE 2.—602 BUFFERS for Metre-gauge Rolling Stock.
SCHEDULE 3.—CYLINDERS, VALVES and PIPING for VACUUM BRAKE.

Tenders due as follows :—
Schedules 1 and 2, 10th May, 1929.
Schedule 3, 14th May, 1929.

Forms of Tender available from the above at a fee (which will not be returned) of 5s. for each Schedule. 1715

Air Ministry. SALE BY TENDER.

TEN PASSENGER RAILWAY COACHES, at present lying at the Royal Air Force College, Cranwell, near Sleaford, Lincs.

The coaches offered comprise the following :—
One First-class Coach of four compartments.
One Second-class Coach of four compartments.
Five Third-class Coaches of five compartments.
Two Composite Third-class Coaches and Brake, each having three passenger compartments.
One Third-class Saloon Coach.

Form of Tender, containing an authority to view, may be obtained upon application being made to the DIRECTOR OF CONTRACTS, Air Ministry, Kingsway, London, W.C. 2.

Tenders due for return 28th May, 1929. 1691

Crown Agents for the COLONIES.

COLONIAL GOVERNMENT APPOINTMENTS.

APPLICATIONS from qualified candidates are INVITED for the following POST :—

M/994.—CIVIL ENGINEER REQUIRED by the GOVERNMENT of SIERRA LEONE for the PUBLIC WORKS DEPARTMENT for two tours of 12 to 18 months' service, with possible extension. Salary £690, rising by annual increments to £920 a year ; outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, 30 to 35 years of age, must have passed Sections A and B of the examination to qualify for the A.M.I.C.E. Diploma or hold professional qualifications accepted by the Institution of Civil Engineers as exempting from these examinations. Must be good Draughtsmen, capable of Designing and Carrying-out Buildings Bridges, and other Engineering Structures, and of Taking-out Quantities and Preparing Detailed Plans and Estimates. They must be competent to Execute Surveys and to Lay-out and Construct Roads, and should have had practice and general experience as Civil Engineers in construction of Roads, Buildings and other Public Works.

Apply at once by letter, stating age, whether married or single, and full particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/994. 1706

Draughtsman, Grade 3, REQUIRED for Instrument Design Work. Candidates must have had good technical training and some Drawing-office Experience on Small Mechanical Apparatus.

Salary, 40s. to 52s., plus Civil Service bonus per week, depending on experience. Equivalent total remuneration, 66s. 2d. to 82s. per week.

Preference given, other things being equal, to an ex-Service man.

Write, quoting reference No. A 335, stating age and giving full particulars of training and experience, to the CHIEF SUPERINTENDENT, Royal Aircraft Establishment, South Farnborough, Hants. 1689

Royal Corps of Naval CONSTRUCTORS.

A COMPETITIVE EXAMINATION for a POST as PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the Royal Naval College, Greenwich, during the first fortnight in July next.

Candidates must not be more than 24 years of age on 1st October next, and must then have been engaged in practical shipbuilding work for at least 18 months. Graduates from the Universities are preferred.

The salaries and other conditions of service are given in full in the regulations of the Royal Corps of Naval Constructors. The salaries during the two or three years' Greenwich course, including cost of living bonus reckoned at its present rate of 70, are approximately as follows :—

Probationary Assistant Constructors on joining R.N. College, £190, in addition to mess allowance,

Probationary Assistant Constructors during second half of course, £220, in addition to mess allowance.

Candidates successful at the end of the R.N. College course will be admitted into the Royal Corps of Naval Constructors as permanent Civil Servants, with corresponding superannuation and other privileges, the salaries, including bonus as above, of the lower grades being approximately as follows :—

2nd Class Assistant Constructor (first 3 years), £320-£360.

1st Class Assistant Constructor (after 3 years), £430, rising to £710.

The salaries, &c., for the higher grades are stated in the regulations, which may be obtained from the Secretary of the Admiralty (C.E. Branch), Whitehall, S.W. 1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience not later than Saturday, the 11th May next.

Applications for the regulations should be accompanied by an addressed foolscap envelope.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE.

A QUALIFYING EXAMINATION will be held in conjunction with the above, for the admission to the Royal Naval College, Greenwich, of PRIVATE STUDENTS of NAVAL ARCHITECTURE who desire to receive instruction in the course laid down for Probationary Assistant Constructor. Application for admission as Private Students should reach the SECRETARY OF THE ADMIRALTY (C.E. Branch) not later than the 11th May next.

Private students are required to pay a fee of £50 per session. 1569

Crystal Palace School OF PRACTICAL ENGINEERING.

Principal : MAURICE WILSON, M.I.C.E., F.S.E.
Vice-Principal : F. C. P. LAWRENCE, M.S.E., A.M.I. Struct. E.

SUMMER TERM COMMENCES WEDNESDAY, MAY 1st. 1657

The Engineer

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PUBLIC NOTICES

Ministry of Transport. ROADS DEPARTMENT.

TEMPORARY ENGINEER.

APPLICATIONS are INVITED for a TEMPORARY APPOINTMENT as ENGINEER attached to the Southern Division of the Roads Department, with headquarters at Exeter. Salary, £400 per annum inclusive.

Candidates, with experience under a Highway Authority and practical experience of modern Road and Bridge Construction are required. Preference will be given to men who have served in His Majesty's Forces.

Applications for forms of application should be made in writing to the ESTABLISHMENT OFFICER, Ministry of Transport, Whitehall-gardens, S.W. 1. Last day for receipt of application forms, 10th May. 1690

Tracer Required.

Salary 25s. plus cost-of-living bonus ; present total salary 42s. 6d. per week. If otherwise suitable, preference will be given to ex-Service applicants.—Apply by letter to THE COMMANDANT, Experimental Station, Porton, near Salisbury. 1714

Corporation of Durban, Natal.

The Corporation of Durban, Natal, invites TENDERS for the SUPPLY and DELIVERY c.i.f. Durban, and, alternatively, Stores, Durban, of 10 Miles of TRAM RAILS, complete with Tie Bars, Fish-plates and Bolts ; also SPECIAL TRACK WORK and RAIL BONDS, to be approved by the Representative Engineers, Messrs. W. H. Radford and Son, Albion Chambers, King-street, Nottingham.

On deposit of £2 2s., returned on receipt of bona fide Tender, specifications can be obtained from, and sealed and endorsed Tenders must be delivered to, the undersigned, on or before Monday, May 6th, 1929.

The lowest or any Tender will not necessarily be accepted.

By Order,
WEBSTER, STEEL and CO.,
36, Leadenhall-street,
London, E.C. 3
1712 Agents to the Durban Corporation.

PUBLIC NOTICES

Clayton-le-Moors and Great HARWOOD JOINT SEWERAGE BOARD.

ADDITIONS AND ALTERATIONS TO TREATMENT WORKS.

CONTRACT No. 1.
TO CONTRACTORS.

The above Sewerage Board are prepared to receive TENDERS for the CONSTRUCTION of ADDITIONAL WORKS, including Enlargement of Tanks, Construction of Three Filter Beds, Pipe Connections and other works at their Sewage Works in the Great Harwood Urban District, about 2 miles from Clayton-le-Moors, in accordance with the drawings, general conditions, and specification prepared by the Engineers, Messrs. John Taylor and Sons, Caxton House, Westminster, S.W. 1.

The specification, bill of quantities and form of Tender may be obtained from, and the drawings seen at, the office of the Engineers, or at my office, on payment of a deposit of £5 (cheque only), which will be returned on receipt of a bona fide Tender within the prescribed time.

Sealed Tenders, endorsed "Addition to Sewage Treatment Works," must be delivered to me at my office not later than Twelve Noon on Tuesday, the 14th May, 1929.

The Board does not bind itself to accept the lowest or any Tender.

By Order,
(Sgd.) P. HAWORTH,
Clerk to the Board.
Clayton-le-Moors and Great Harwood Joint Sewerage Board,
Bancroft Chambers,
Town Hall-street,
Great Harwood. 1656

Cumberland and Westmorland. JOINT MENTAL HOSPITAL, CARLISLE.

WANTED, NON-RESIDENT WORKING ASSISTANT ENGINEER, to Take Charge (under the Engineer) of Boilers, Steam, Water and Electrical Plant. Age not exceeding 40 ; gross wage, £4 4s., subject to deductions under the requisite Acts. —Forms on which alone applications will be received, and particulars of duties will be supplied, on receipt of stamped addressed foolscap envelope, by C. W. ALLAN HODGSON, Clerk to the Visitors, County Offices, Carlisle. 1681

PUBLIC NOTICES

South Indian Railway Com- PANY, LIMITED.

The Directors are prepared to receive TENDERS for the SUPPLY of :—

SPARE PARTS for TRAIN LIGHTING CELLS (Wood Sheet Separators).

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Spare Parts for Train Lighting Cells," with the name of the firm tendering, must be left with the undersigned not later than Twelve Noon on Friday, 10th May, 1929.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for each copy of the specification.

A. MUIRHEAD,
Managing Director.
91, Petty France, Westminster, S.W. 1.
24th April, 1929. 1713

Metropolitan Water Board. ERECTION OF CAMPSHEETING ALONGSIDE THE RIVER MOLE.

The Metropolitan Water Board invite TENDERS for the ERECTION of CAMPSHEETING alongside the River Mole, near the Board's Island Barn Reservoir, in the Parish of East Molesey.

The drawings and contract documents may be inspected without charge at the Offices of the Board, Chief Engineer's Department (Room 201).

Forms of Tender, conditions of contract, specification, and drawings may be obtained on and after Monday, 29th April, 1929, from the Chief Engineer on production of an official receipt for the sum of £5, which must be deposited with the Accountant to the Board, and which will be returned on receipt of a bona fide Tender, accompanied by all the above-named documents and drawings. Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board, and endorsed "Tender for Campsheeting, River Mole," must be delivered at the Offices of the Board (Room 122) not later than 11 a.m. on Tuesday, 21st May, 1929.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
173, Rosebery-avenue, E.C. 1.
26th April, 1929. 1652

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

BOX No. 1321 Advertisement Appeared March 22nd issue, commencing "Vacancy exists in Testing Department." This VACANCY has now been FILLED. 1688 A

WANTED for Canadian Company, Experienced DETAILERS and CHECKERS for Structural Steel and Bridge Building. Highest salaries to competent men.—Apply immediately by letter only to W. B. C., c.o. John Coates and Co., Ltd., Victoria House, Melbourne-place, Strand, London, W.C. 2. 1700 A

WANTED for Large Iron and Steel Works in South Wales, ASSISTANT ELECTRICAL ENGINEER, accustomed to A.C. systems.

State age, experience, and salary required, with copies of three recent testimonials.

Address, 1664, The Engineer Office. 1664 A

WANTED, PLANNING and PRODUCTION ASSISTANT for Aircraft Factory. Applicant must be prepared to take charge of the preparation and layout of modern All-metal Aircraft Production, and must have a full knowledge of up-to-date methods, particularly with regard to Rolling, Drawing, Pressing, Blanking and Riveting. Permanent job for capable man. Applicants should give full details of past experience with copies of references, if possible, and should state salary required.—Address, 1621, The Engineer Office. 1621 A

WANTED, PRODUCTION SUPERINTENDENT for large works in North of England dealing with batch production. Applicants must have had thorough works experience in this type of production and be accustomed to handling all matters connected with shop orders, progress, chasing, bulletin boards, &c. Excellent opening for keen man who can show good record. Mass production men need not apply.—Address, 1642, The Engineer Office. 1642 A

WANTED, Thoroughly Competent Young and energetic MAN who has been thoroughly trained in Boiler and Tank Building ; must be well up in the latest practice of Hydraulic and Pneumatic Riveting and Electric Welding. Permanent situation and good salary for the right man.—Address, stating age, salary, and experience, 1687, The Engineer Office. 1687 A

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CONSTRUCTIONAL ENGINEERS in London REQUIRE SERVICES of STEEL WORK DESIGNER with experience in this class of work. Please give full particulars, age, salary, &c. Permanent position.—Address, 1591, The Engineer Office. 1591 A

CIVIL ENGINEER, A.M.I.C.E., Aged 30-35, unmarried, with experience Railway Construction, REQUIRED for Brazil.—Write, stating experience and qualifications, "H. F.," c/o J. W. Vickers and Co., Ltd., 24, Austin Friars, E.C. 2. 1650 A

ESTIMATOR and TIME STUDY MAN REQUIRED, capable of estimating costs and tendering for Aero-engine Components and Details. State in detail length of experience, where acquired, age, and wage required.—Address, 1625, The Engineer Office. 1625 A

INSPECTION SUPERINTENDENT REQUIRED for works employing about 2000 hands. Candidates must be used to latest methods of interchangeable manufacture and accustomed to controlling first-class product. Applicants should enclose photographs, which will be returned.—Address, 1643, The Engineer Office. 1643 A

OLD-ESTABLISHED ENGINEERING COMPANY in India REQUIRE a YOUNG MAN of good address and personality; not over 23, must be single, with technical training and Salesmanship Experience in Engineers' Hardware or Iron and Steel.—Reply fully, stating age, education, training and experience, also present employment, and salary, to Z.Z. 952, care of Deacon's Advertising Agency, Fenchurch-avenue, E.C. 3. 1711 A

POSITION OPEN for First-class SALES ENGINEER for Steam Plant Speciality for North of England.—Address, stating experience, salary required, 1692, The Engineer Office. 1692 A

POWER-HOUSE ENGINEER REQUIRED for Nitrate Factory in Chile, to Take Charge of Diesel Engines (M.A.N.), and Electrical Plant. Knowledge of Spanish preferable.—Address, P5768, The Engineer Office. P5768 A

REQUIRED, EXECUTIVE ENGINEER for Abroad, with Mechanical and Civil Experience, age 30-36, to assist Chief Engineer on General Constructional Work, including Steel Buildings, Pumps, Storage Tanks, also Reinforced Concrete and General Masonry Work, &c. Knowledge of Portuguese or Spanish desirable. Full particulars as to age, education, training, and experience, with copies of testimonials. Good salary to competent man.—Write, Box M. 897, Willing's, 133, Moorgate, E.C. 2. P5758 A

REQUIRED for Ceylon, MECH. ENGINEER, with general exp., unmarried, age 24/6; knowledge of Estimating, Oil Engines, Drawing-office, &c., a recommendation.—Address, with copies only of testimonials, P5766, The Engineer Office. P5766 A

THE BRITISH STEELWORK ASSOCIATION, recently formed with the object of increasing the uses of structural steel by means of research, publicity, and propaganda, REQUIRES a fully qualified ENGINEER as DIRECTOR. He must possess literary ability and have good presence and address. Age 35/45. Knowledge of French and German an advantage.—Applications should be made by letter, giving particulars and salary required, to Messrs. PEAT and CO., 11, Ironmonger-lane, E.C. 2. 1707 A

TRAVELLER. Thoroughly Acquainted with the Grinding Wheel Business and with good connection, WANTED to further the sale of a high-grade wheel; commission and part expenses.—Address, 1705, The Engineer Office. 1705 A

YOUNG, Public School, South Country, MECHANICAL ENGINEER REQUIRED as Assistant Sales Engineer in Scotland. State fully experience and salary.—Address, 1653, The Engineer Office. 1653 A

WANTED, DRAUGHTSMAN, Used to the Design of Medium-weight Machine Tools. State age, wages, and experience.—Address, WEBSTER and BENNETT, Ltd., Coventry. 1644 A

WANTED IMMEDIATELY, DRAUGHTSMAN, with experience in modern Central Heating and Hot Water Supply Plants. Must be accustomed to estimating and preferably experienced in Cooking and Laundry Installations. Age 25 or over.—Address, 1672, The Engineer Office. 1672 A

WANTED, CHIEF DRAUGHTSMAN, with Intimate knowledge of design of High-speed Petrol Engines; a knowledge of Diesel Engine design also a recommendation.—Address, stating full experience and wages required, 1673, The Engineer Office. 1673 A

WANTED IMMEDIATELY, Thoroughly Competent CHIEF DRAUGHTSMAN for all classes of Railway Wagon Work, home and foreign.—Apply by letter in the first place, stating age, experience, and salary required, to MANAGING DIRECTOR, Charles Roberts and Co., Ltd., Horbury Junction, near Wakefield. 1683 A

WANTED IMMEDIATELY, TWO Thoroughly Competent RAILWAY WAGON DRAUGHTSMEN. Must have had training in the design of Steel Railway Wagons.—Apply, stating age, experience, and salary required, to CHARLES ROBERTS and CO., Ltd., Horbury Junction, near Wakefield, by letter in the first place. Good opening for the right man. 1671 A

A FIRM of BANKERS' ENGINEERS, with Works in North London district, REQUIRE a JUNIOR DRAUGHTSMAN, age 18/20.—Address, stating experience and salary required, P5757, The Engineer Office. P5757 A

ASSISTANT ELECTRICAL ENGINEER REQUIRED for a large Tin Mine in Perak, Federated Malay States. Salary 350 dollars to 400 dollars per month (dollar equals 2s. 4d.), with furnished quarters. Applicants should have received a thorough training and have exeriences in supervising Alternating-current and High-tension Transmission Systems. Active, unmarried man, 30-35 years of age preferred.—Apply in writing, with copies of testimonials, to ADAMSON, GILFILLAN and CO., Ltd., 2, Billiter-avenue, London, E.C. 3. 1701 A

ASSISTANT ENGINEER REQUIRED for Service with Oil Company operating in Venezuela; single, age 25/30. Candidates should have obtained an Engineering Degree at one of the Universities or having served a regular apprenticeship, supplemented that by obtaining an Engineering Degree or Diploma at one of the recognised training colleges and have had several years' practical experience. Salary 275 dollars (U.S.A. currency) per month. Three years' engagement with first-class passage out and home on completion of agreement, and outfit allowance provided. Selected candidate will be required to be passed as medically fit for tropical service.—Apply, stating age and giving full particulars, to Z.A. 973 care Deacon's Advertising Agency, Fenchurch-avenue, London, E.C. 3. 1708 A

ASSISTANT SUPERINTENDENT REQUIRED for Works Rolling and Drawing Special Sections in Steel and Non-ferrous Alloys. Must have first-class experience and be able to design tools, control annealing, &c.—Address, stating experience and salary expected, 1583, The Engineer Office. 1583 A

DRAUGHTSMAN for Structural and General Foundry Maintenance Work REQUIRED.—Address, stating if at present employed, experience, and salary required, P5761, The Engineer Office. P5761 A

DRAUGHTSMAN REQUIRED by London Firm of Centrifugal Engineers for general arrangements, details and installations. Practical experience essential. State age, experience, and salary required.—Address, 1668, The Engineer Office. 1668 A

DRAUGHTSMAN WANTED for Plant and Machinery development. Only men with experience need apply. Give full experience, wages reqd.—S. SMITH and SONS, Cricklewood Works, N.W. 2. 1670 A

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ESTIMATING ENGINEER and DRAUGHTSMAN, with thorough scientific and practical knowledge of Steam Engineering.—Address, stating particulars, salary required, and date able to commence, 1693, The Engineer Office. 1693 A

JIG and TOOL DRAUGHTSMEN, Senior and Junior, REQUIRED, Commercial Vehicle Manufacturers near London.—Address, stating experience, age, and wage required, 1695, The Engineer Office. 1695 A

JUNIOR DRAUGHTSMAN, About 24 Years, WANTED temporarily in Westminster for MECHANICAL details. Give full particulars and salary required.—Address, 1568, The Engineer Office. 1568 A

JUNIOR DRAUGHTSMAN REQUIRED for Engineering Works specialising on Worm Reduction Gears and Advertising Devices. Opportunity given for practical experience.—Letters, giving experience, salary required, &c., MORTIMER ENGINEERING Co., Acton-lane, Harlesden. P5748 A

JUNIOR MECHANICAL ENGINEER REQUIRED by large gas undertaking, age 21 to 24, well educated and fully trained; preference given to public school boy with railway shop training. Prospects good, pension fund and co-partnership scheme on completion of one year's satisfactory service. State salary required.—Address, 1584, The Engineer Office. 1584 A

LONDON STRUCTURAL ENGINEERS REQUIRE DETAILING DRAUGHTSMEN. Previous experience necessary. Full particulars, age, salary, &c.—Address, 1592, The Engineer Office. 1592 A

OLD-ESTABLISHED FIRM of CONSTRUCTIONAL ENGINEERS in India REQUIRE a STRUCTURAL DRAUGHTSMAN for Bridge, Roof and Structural Steel, and capable of working out stresses; age not over 25, unmarried.—Reply, giving fullest details education, experience, present work, and salary, to Z.Y. 951, care of Deacon's Advertising Agency, Fenchurch-avenue, E.C. 3. 1710 A

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For continuation of Small Advertisements see page 4.

A Seven-Day Journal

Scale Effect.

IN a leading article in our issue of March 22nd, dealing with the passage from model experiments to full-scale construction, we discussed the question of scale effect and the manner in which it is sought to eliminate it by conducting the model tests at Reynolds' numbers comparable with those of the full-scale conditions. In the annual report, just issued, on the work of the National Physical Laboratory we find an example, which may be placed alongside the aeronautical example mentioned in our leading article, illustrating the uncertainty which at times attends the assessment of the scale effect. Of three ships, the models of which were tested in the National Tank, one required materially more power than was estimated from the model tests, one required materially less power, and the third showed perfect agreement. In the case of a fourth vessel the revolutions and power required for propulsion were 1 per cent. and 4 per cent. respectively above the figures deduced from the model tests. It is noted that two vessels, a P. and O. liner and a high-speed cross-Channel steamer, of which the models have been tested at the tank, will be available this year for very complete measurements as regards speed, thrust and power. On the aeronautical side the question of scale effect is being attacked by the construction of a high-pressure wind tunnel. Erection of this tunnel and of the building to house it will be begun this summer. The tunnel will be contained in a steel cylinder 17ft. in internal diameter with a length over its hemispherical ends of about 50ft. The walls of this cylinder will be about 2½in. thick, to withstand a pressure of 25 atmospheres. Three compressors of 400 horse-power each will be installed and will permit a pressure of 25 atmospheres to be reached in eighty minutes. The diameter of the working section will be 6ft., and through it the air will be circulated at a speed of about 80ft. per second by means of a motor absorbing 400 horse-power at the highest working pressure. In this tunnel the full-scale Reynolds number will be reached with a model to a scale of one-twelfth and with wind speeds equal to half those of actual flight.

London's Bridges.

THE negotiations begun last July between the Southern Railway Company and the London County Council concerning the proposal to remove Charing Cross Railway Station to the south bank of the Thames and to construct a road bridge on the site of the existing bridge and station would appear to be making a certain amount of slow progress. At Tuesday's meeting of the London County Council it was reported that the Southern Railway had submitted a statement of the heads under which it proposed to ask for compensation in connection with the scheme. That statement had been reported upon by the Council's officers and the report had been sent to the Ministry of Transport. To-day, Friday, Sir Percy Simmons is meeting the Minister of Transport with a view to discussing the report, and following this interview it is hoped that it will be possible to arrange a round-table conference to expedite the business. Meanwhile the Council is postponing taking a decision with regard to Waterloo Bridge. It is four years since the wooden supports were placed under Rennie's famous structure. Their life is necessarily limited. The foundations of the temporary steel bridge erected alongside the old one cannot, the Council is advised, be relied upon for an extended period. Expenditure is being incurred on the maintenance of the two bridges, but a final decision as to the rebuilding or replacing of Waterloo Bridge will not be taken until the negotiations with regard to Charing Cross Bridge have reached a satisfactory conclusion.

Projected American Battleships.

ACCORDING to a Press message from Washington, the United States Navy Department proposes to build two 35,000-ton battleships in replacement of three existing vessels which will shortly become obsolete, viz., the "Florida," "Utah," and the "Arkansas" or "Wyoming." The ships named were completed in 1911–12 and armed with 12in. guns, each of the first two mounting ten and each of the second pair twelve of these weapons. They have recently been modernised at heavy cost, the boilers having been converted from coal to oil burning. Bulges and extra deck armour have also been fitted. Although this renovation has given them a new lease of life, they can no longer be rated as first class, and it is but natural that the American naval authorities should wish to replace them by ships of post-Jutland design. Under the Washington Treaty, however, battleship construction may not be resumed by any of the signatory Powers, except France and Italy, before 1931, so that nearly two years must elapse ere the keels of the two projected vessels can be laid. The present announcement is of interest as denoting the unshaken faith of American naval experts in the battleship. It may also be interpreted as a challenge to the British view that future battleships should be restricted in tonnage and armament to figures below the maxima established by the Washington covenant. Great Britain has more than once proposed a limit of 25,000 tons displacement and 13·5in. gun calibre. Apparently, however, American naval opinion prefers to adhere to the Treaty standard of 35,000 tons and 16in. guns. These matters will doubtless be discussed at the international naval conference to be held in two years time, though it is unlikely that American opinion will undergo any modification in the interim.

A Large Motor Lifeboat.

IN a Journal paragraph of March 29th we referred to some of the large motor lifeboats recently presented by leading shipping companies for the service of the Royal National Lifeboat Institution. On Wednesday last official trials were run at Cowes of the new 61ft. motor lifeboat "Princess Mary," built by S. E. Saunders, Ltd., which will be stationed at Padstow, Cornwall, and which was presented by the P. and O. group of shipping companies through Lord Inchcape. The new boat is claimed to be the largest of the type in the world. She has a beam of 15ft. and displaces 45 tons of water. Her excess buoyancy derived from fifteen main and one hundred minor water-tight compartments is equal to nearly one and a-half times her weight, so that even if she be severely damaged she will remain afloat and manageable. The propelling machinery comprises two six-cylinder 80 brake horse-power, 800 r.p.m., petrol motors of the new completely submersible type, which was described in our issue of February 17th, 1928. These engines are designed to give the boat a speed of 9 to 10 knots, with sufficient reserve power to enable her to travel at full speed under practically any conditions of weather. Two cabins, each capable of accommodating from fifty to sixty persons, are provided. In a calm sea about 300 persons could stand on the decks, while in the worst of weather 150 people could be safely carried in addition to the crew. About 500 gallons of petrol are carried, or sufficient for a cruising range of 500 miles at a speed of 8 knots. Jets are fixed in all compartments for the smothering of fire by foam, and an arrangement is fitted whereby oil can be sprayed on the sea from the bows of the boat.

New Cross-Channel Motor Vessels.

AN interesting event took place at Harland and Wolff's Belfast yard yesterday, Thursday, April 25th, when a number of engineers, shipbuilders and other guests accepted the invitation of the Belfast Steamship Company, Ltd. (Ulster Imperial Line), to witness the launch of the third Belfast-Liverpool motor ship, "Ulster Prince," which will be commissioned in June. The second vessel, the "Ulster Queen," is being fitted out for service in May, and after the launching ceremony the "Ulster Monarch," which will be commissioned this month, was inspected and a cruise made on her in Belfast Lough. These new vessels are noteworthy, as they are the largest cross-Channel motor ships in the world. They have a length of 345ft. with a beam of 46ft. and a moulded depth of 19ft., with a measurement of 3760 gross tons. The lines of the ships are very pleasing and the two distinctive "motor ship" funnels give an attractive appearance. The design of the public rooms and cabins is very modern in style, and high-class accommodation is furnished for 419 first-class and 86 third-class passengers. Most of the first-class passengers are accommodated in single-berth state-rooms, with a few double-berth cabins, while for the third-class passengers two and four-berth cabins are provided. An interesting detail is a telephone box which is connected to shore lines when the vessel is in port. The propelling machinery for each ship consists of a twin-screw arrangement of ten-cylinder airless injection oil engines of the Harland-B. and W. four-stroke single-acting type. Most of the auxiliary machinery in the ship is electrically operated, and in order to furnish current for lighting and power supply three six-cylinder airless injection oil-electric generating sets are employed.

The Vestris Inquiry.

THE official Board of Trade inquiry under Section 466 of the Merchant Shipping Act into the sinking of the 10,900 gross tons passenger and cargo liner "Vestris," which took place with a loss of 112 lives off the coast of America on November 12th last, was opened on Monday last in the Great Hall of the Institution of Civil Engineers. The presiding Wreck Commissioner is Mr. Butler Aspinall, K.C., who is assisted by five assessors, Vice-Admiral E. L. Booty, Engineer-Lieutenant Commander W. M. Fletcher, Major H. S. Hambling, Captain H. P. Learmont, and Captain F. J. Thomson. In his opening statement for the Board of Trade the Attorney-General, Sir Thomas Inskip, K.C., outlined the general sequence of events leading up to the sinking of the vessel, and stated that in the inquiry attention would be directed mainly to three items: first, as to what was the cause, or what were the causes, of the incursion of water; secondly, what caused the vessel to take the list it appeared to have taken at an early stage in the voyage, which grew larger with increasing wind and sea; and thirdly, what led to the very heavy loss of life which resulted. Questions, he said, had been drawn up for the court to answer which related to the ship and her owners, what sort of instructions were given, and what happened in the course of loading, what was the ship's equipment and how was she fitted out and officered and manned, and what took place during the voyage. Technical evidence was given on Monday and Tuesday by Mr. A. W. Downs, assistant draughtsman to Workman, Clark (1928), Ltd., who produced plans and specifications relating to the construction of the ship and her double-bottom tanks, pumping and coal bunkering arrangements. Mr. Alfred Woods, the general manager of Lamport and Holt, Ltd., of Liverpool, gave evidence with regard to the Liverpool, Brazil and River Plate Navigation Company, the owners of the ship, and Lamport and Holt, Ltd., her managers. Later on the loading of the vessel at New York was inquired into.

Weak Bridges.

THROUGHOUT the country, and particularly in the Midlands, certain bridges over canals and railways, which by law are not required to be maintained by their owners in a condition superior to that which was necessary to suit the traffic in the days when they were erected, have proved a great hindrance to modern road traffic. In the Midlands about a hundred bridges across the canals are in this condition, and as a consequence traffic over them is restricted by order of the canal companies. Traders and manufacturers have undoubtedly been put to great inconvenience and delay by these restrictions, and for some time there has been a strong movement in favour of the strengthening of the bridges in question. Under the Bridges Bill now before Parliament, local authorities will be empowered to take over and maintain the bridges in their districts, which, by reason of their owners' statutory obligations, have ceased to be fit for modern traffic. Last week a deputation from the Association of Municipal Corporations waited on the Minister of Transport with the object of laying before him the view that power to take over the bridges would not meet the situation unless it were accompanied by substantial Government assistance towards the cost of reconstructing them. A grant of 75 per cent. of the net cost, irrespective of the classification of the road on which the bridges were situated, was suggested. Colonel Wilfrid Ashley, replying, said that half a million pounds was to be provided from the Road Fund this year for the abolition of weak bridges and of level crossings. While he could not give an unconditional promise of any particular percentage grant in every case, he contemplated that the normal grant should be 75 per cent. of the net cost. The Minister's statement was received with much satisfaction by the deputation and has given equal satisfaction in the districts affected.

Important New Shipbuilding Orders.

ORDERS for no less than eighteen large passenger and cargo steamers were recently placed by the Cia. de Nav. Lloyd Brasileiro, of Rio de Janeiro, Brazil, with Scott's Shipbuilding and Engineering Company, Ltd., of Greenock, and the Burntisland Shipbuilding Company, Ltd., of Burntisland, Fifeshire. The ships will, we understand, be propelled by triple-expansion engines and their total cost will represent an expenditure of about two million pounds. The actual number of ships allotted to each firm and the size of the new steamers have yet to be announced. Another important Clyde order is that placed by the Bibby Steamship Company, Ltd., of Liverpool, with the Fairfield Shipbuilding and Engineering Company, Ltd., of Govan, Glasgow, for a new Shire motor liner of the "Staffordshire" class. The new liner will be somewhat larger than the "Staffordshire" and will embody improvements in design. On the Tyne Sir W. G. Armstrong, Whitworth and Co., Ltd., recently received an order from Norwegian owners for a motor tanker generally similar to the "Binta," constructed for the same owners last year.

Consultation and Co-operation in Industry.

ON Tuesday representatives of the General Council of the Trades Union Congress, of the National Confederation of Employers' Organisations, and of the Federation of British Industries met in conference in London as an outcome of the invitation extended to the trades union organisation on February 13th by the Confederation and Federation. The chair was occupied by Lord Gainford. The opening statements were made by Sir Ralph Wedgwood on behalf of the Confederation, by Mr. Lennox Lee on behalf of the Federation, and by Mr. Ben Tillett on behalf of the General Council. Following a general and comprehensive discussion, it was resolved to adjourn the conference to consider the appointment of representatives from each organisation to be a committee to examine the best methods for consultation and co-operation between the three organisations. Certain legal and other difficulties will have to be surmounted before any scheme of consultation and co-operation can be adopted, but that the three organisations now stand committed to the principle of consultation and co-operation and have at their first meeting unanimously decided to appoint a joint committee to discuss the best means of making that principle effective is regarded by many as a very hopeful sign.

The Shannon Power Scheme.

No. I.

SINCE the publication of our previous series of articles on the Shannon power scheme,* considerable progress has been made with all branches of the work, and it is expected that the generating plant will be put into operation towards the end of this year. The power-house, together with its adjacent buildings—shown in the drawing, Fig. 1—is rapidly approaching completion, the turbine casings—see Fig. 2—have been in position for some little time, and the three penstocks—Fig. 3—have been carried up to the intake sluice building—Fig. 4—the superstructure of which is so far advanced as to give a clear idea of its final appearance. The power-house consists of several parts quite separate in themselves and in their purposes, although they are interconnected to form a single building. Associated with the power-house proper is the 38-kV switch house, on the right when looking down the tail-race, and the 10·5-kV switch house at right angles to it. On the tail-race side of the 38-kV switch house there is a building for housing the oil refining plant and transformer workshop, which is practically complete. A view of the 38-kV switch house in the course of construction and showing some of the steelwork for the power-house is given in Fig. 5. For the purpose of raising the pressure to 110,000 volts and 38,000 volts, transformers have been erected. The generator hall is built up of massive steel structures interconnected by steel girders—see Fig. 7, They rest on steel hinged bearings, mounted on concrete foundations, the object of these bearings being to allow for slight movement caused by temperature variations. The spaces between the vertical members of the framework along the building are filled with concrete, so that from the outside the building cannot be distinguished from a concrete one.

Two 100-ton overhead cranes will eventually run over the whole of the generating hall, and when the station is complete they will be used for lifting heavy machine parts when repairs are being undertaken and for placing the three additional generators in position when it becomes necessary to extend the station for the full development scheme. The annexes to the power-house consist of transformer rooms, control rooms for the turbines and generators, and store rooms situated below the floor level of the generating hall and projecting towards the 38-kV switch house, thus providing a clear working space for assembling machinery and for future repairs. The floor of the store-rooms is at the same level as that of the Great Southern Railway, one branch of which actually runs into these rooms, thus enabling goods to be brought directly to the spot. A large opening cut in the floor of the generating hall immediately above the railway and stores will facilitate the supply of materials from the store-room or from the railway tracks to the generating hall.

The penstocks—to be seen in Fig. 3—have a slope of 31 deg. to the horizontal. At the bottom the tubes bend horizontally and then taper gradually from a diameter of 6 m. to 4·8 m., at which point they connect with the spiral casings, which are so designed as to supply the water to the turbine rotor at all points over the periphery with the highest degree of efficiency. They are built up of tapering steel sections, riveted together on site and varying in thickness from 18 to 11 mm., according to the decreasing diameter of spiral. The sections are riveted on the inside to the speed ring for the purpose of strengthening the spiral casing and obtaining a streamlined flow of water to the guide mechanism of the turbine.

These speed rings which are in two parts—as shown in Fig. 6—consist of solid steel castings, comprising an upper and lower disc connected together and strengthened by twelve upright struts designed so that they will be of least resistance to the waterflow. Connected to the inside flanges of the speed ring, above and below, are two further discs which house twenty-four movable guide vanes, approximately 1·3 m. high, for regulating the waterflow to the turbine runner inside and controlled by the oil governor. The water enters the runner in a horizontal direction, and leaves it vertically through a steel draught tube, which tapers in diameter from 4 to 4·8 metres over a distance of 2·5 metres. The object of using a steel draught tube is to ensure a good connection of the turbine with the foundations, and the tube is completely concreted in and securely held in correct position by riveting to several rag bolts. To facilitate inspection of the runner a watertight door is provided in the centre of the steel draught tube. The spiral casings have been erected on steel shoes, securely bolted to foundation blocks, and are

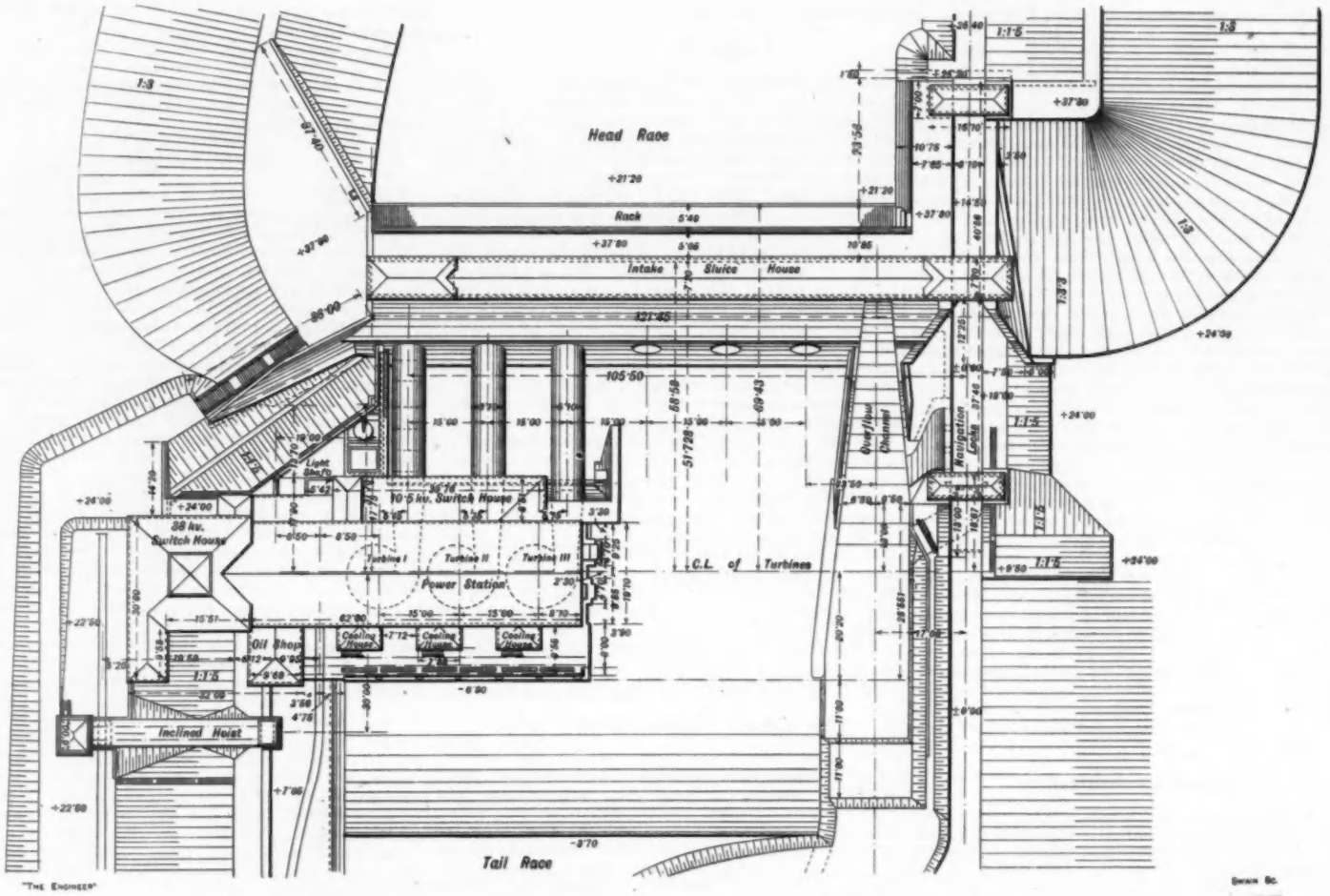


FIG. 1—POWER-HOUSE AND ADJACENT BUILDINGS

FIG. 2—TURBINE SPIRAL CASINGS IN POSITION

* See THE ENGINEER, December 2nd, 9th, 16th, 23rd, 1927; and March 23rd and 30th, 1928.

completely bedded in concrete and anchored by numerous rag bolts.

When pouring the concrete, special care was taken to avoid spaces between the spiral casing and the encasing concrete and to prevent any movement in the flowing concrete. Full details of the turbines were given in a previous series of articles.

The three 30,000-kVA transformers for raising the pressure to 110,000 volts, together with their cooling houses, are situated on a terrace on the tail-race side of the generator hall, and on the same level as that of the Great Southern Railway, the cars of which can be shunted on to a track running along the tail-race edge of the terrace by means of a turntable. This rail track serves to bring the railway cars to the transformers, and it also serves as a track for a crane for unloading the trucks, or in case of necessity for placing in position the dam beams that close the outlets of the draught pipes. A water resistance chamber situated behind the power-house and a small auxiliary turbine building also form an annex to the power-house.

The 38-kV switch house on the right side of the generator hall when looking down the tail-race is now almost complete. The structure is composed of reinforced concrete, only the roof being of steel. It is of similar construction to that of the generator hall, already described. The building has three floors, connected by staircases and a lift, and it contains transformer rooms, switch rooms, cableways, battery rooms, stores, a smithy, workshops, offices, &c. From this building most of the cables will emerge, and holes for them have been provided in the north-east wall of the building. In the top storey will be placed the central switchboard, and when it is complete it will control the distribution of current to the whole system of power lines extending over the country. The four-storey 10-kV switch house behind the generator hall is also approaching completion. All windows from the smallest to the largest have steel frames, and all the doors, except for a few in the offices, are entirely of steel as a safeguard in case of fire.

There are altogether in the power-house, including the 38 kV and the 10 kV switch-houses, &c., ninety steel doors, varying in size from 7·50 m. by 4·60 m. to 1·65 m. by 0·50 m., sixteen timber doors and 200 windows, the latter requiring about 11,200 square feet of glass. The largest doors have four panels and are mounted on rollers to facilitate opening and closing. Practically all the doors and windows of the power-house are in position. Some 20 m. from the south-west side of the 38-kV switch-house there is an inclined elevator. This structure lies on the slope of the cutting for the Great Southern Railway and connects this line with another one on top running between the outdoor station and the 38 kV switch-house, and will thus enable all machine and transformer parts for the outdoor station and the 38 kV switch-house to be lifted straight to the top of the cutting in the railway company's cars without unloading them. This structure consists essentially of two concrete beams, 2·50 m. apart centre to centre, laid on to the slopes of the cutting, and each supporting two rails for the trolley of the elevator to run on. At the top there is an electric winch for pulling the cars up, and at the bottom a concrete pit to accommodate the trolley into which the cars will be shunted, locked into position and pulled sideways up the slope to the level of the railway on top. The steel trolley is of such construction that, though the wheels are on a slope, the platform supporting the railway trucks is horizontal. The intake building accommodates the motors and winches for operating the sluices in front of the inlets to the pipes. An overhead crane runs the whole length of the building.

All the excavation work at the site of the main power station was completed towards the end of 1927, when approximately 200,000 cubic metres of earth and 150,000 cubic metres of rock had been removed down to the deepest foundation level of the underground portion of the power station. On account of the higher foundation level of the intake sluice house —see Fig. 4—the excavation work for this was finished first and the concreting work begun at once. The intake building running across the head-race above the power-house is essentially a huge concrete dam or barrage with wing walls splaying from each end into the head-race banks. On the head-race side the dam has six inlets, admitting the water to the 6 m. diameter penstocks bringing the water to the turbines, 30 m. below. Only three of these inlets will be used for the partial development.

FIG. 3—INTAKE AND PENSTOCKS UNDER CONSTRUCTION

FIG. 4—INTAKE BUILDING, DOWNSTREAM SIDE

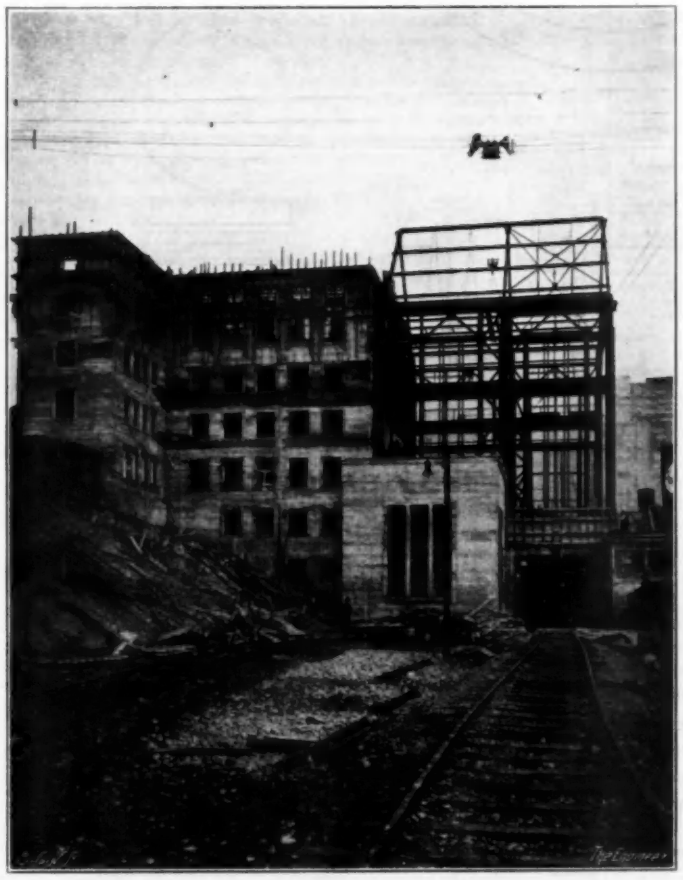


FIG. 5—38 kV SWITCH-HOUSE AND STEELWORK FOR POWER STATION

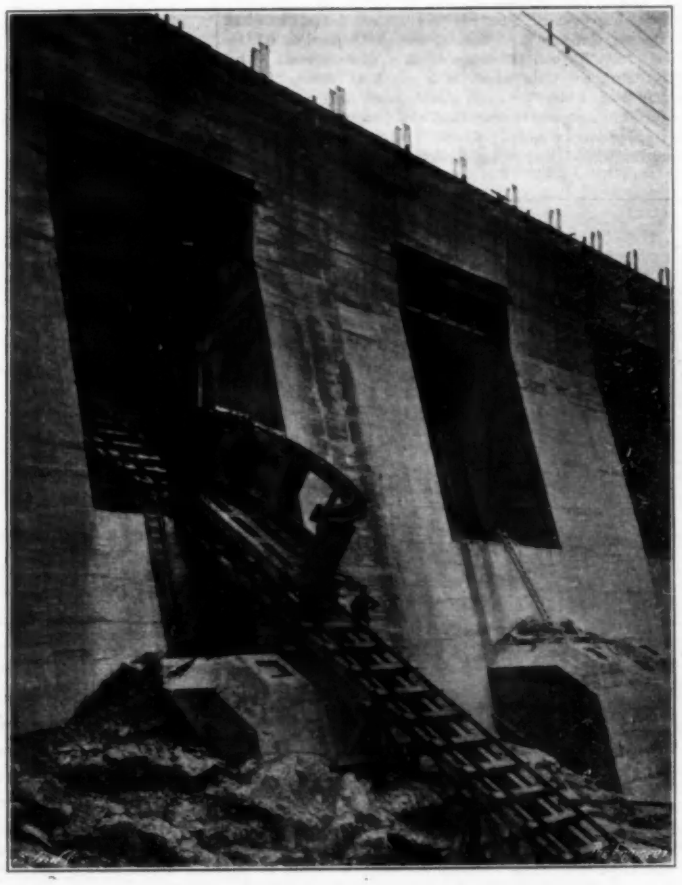


FIG. 6—LOWERING SPEED RING OF A TURBINE

At the extreme east of the structure there are two more openings, one for the waste water channel, the other for the entrance to the navigation locks. The foundation of the intake sluice house is in blue limestone—a rock of high bearing strength—but, in order to obviate the danger of the water percolating from the head-race, through the existing fissures in the underlying strata, it was decided to grout the entire area in question to a depth of 15 m. by pumping cement through pipes into the rock under a pressure of six atmospheres. Many tons of cement grout were used in this work. The foundations for the power-house, being some 30 m. below the foundation level of the

FIG. 7—ERECTION OF STEEL FRAMES FOR GENERATOR HALL

intake sluice house, involved the excavation of thousands of cubic metres of rock. The entire area of the rock foundation was found to be suitable for the stresses allowed in the design, except for a small part, some 400 square metres in area, immediately under the proposed location of the two draught tubes on the extreme west. There, an earth pocket which called for special treatment was discovered. The excavation at this spot was carried down for a further 3 m. over the area mentioned, and a strongly reinforced concrete foundation slab, containing nearly 100 tons of steel was laid down. The construction of the draught tubes, consisting primarily of concrete pipes

FIG. 8—WALLS OF NAVIGATION LOCK

and having a curved longitudinal axis and gradually changing from a horizontal section 4·80 m. in diameter at the turbines to a vertical rectangular one 13 m. × 5 m. at their outlets, 18 m. away from the centre lines of the turbines, was then proceeded with, and in order to obtain an even flow of water from the turbines to the tail-race a great deal of attention was paid to their design.

For a distance of approximately 150 m. a retaining wall beginning at the power-house protects the west side of the tail-race and extends from the bottom of the tail-race to the level of the Great Southern Railway line connecting the power station with Limerick, the height of this wall changing from 15 m. at the power station to 12 m. at the other end. The massive walls of the navigation lock are to be seen in Fig. 8. As the power-house site was excavated for the total development scheme, with six turbines, it has been necessary to erect a temporary partition wall running along the last of the three penstocks and extending 1 m. above the highest water level in the tail-race, in order to protect the back of the power-house from flooding. Adequate provisions have also been made to ensure an easy connection of the remaining half of the power-house with the part now being constructed for the partial development scheme.

Illustrations showing some of the work in the course of construction are given on page 462, where Fig. 9 shows the concreting work for the upper portion of piers Nos. 4 and 5 of the weir, Fig. 10 the concrete work for two ground sluices at the weir, Fig. 11 the power station, intake building, and navigation lock, Fig. 12 the power station and 10-kV switch-house, and Fig. 13 the navigation lock.

(To be continued.)

Kinetic Boundary Friction.

By JUSTIN H. WELLS.

THE physical laws of boundary friction have become widely known, owing to the fundamental investigations of Sir W. B. Hardy, followed by experiments on the machine designed by R. M. Deely, the Daimler Lanchester gear, and the pendulum apparatus of Dr. T. E. Stanton, among others. Observations have been made mainly on static friction, and under conditions in which the opposing surfaces slowly reciprocate or oscillate, or in which fluid friction is not entirely eliminated.

It appeared that experimental data were lacking on the behaviour of boundary films of lubricants under steady shearing or rubbing motion, especially at comparatively high speeds. It was therefore considered that some work on such lines would be useful.

The following article relates to a machine designed with that end in view, and to some of the experiments carried out on it.

DESCRIPTION OF THE APPARATUS.

The surfaces between which the friction is measured virtually constitute a collar bearing with the axis of rotation vertical. The rubbing surfaces are two narrow rings of 1¼in. mean diameter, and the actual contact face may be from about 0·075 to 0·5 square inch. The rings are readily detachable from their housings, so that they can be chemically cleaned and lapped truly flat. The lower ring beds on the bottom of an annulus in a housing, and is prevented by three radial grub screws from rotation relatively to its housing. The housing itself is rotated steadily by a vertical spindle—see Fig. 1—running in the centre column rigidly fixed to the casting forming the base plate.

The upper friction surface is located by a register

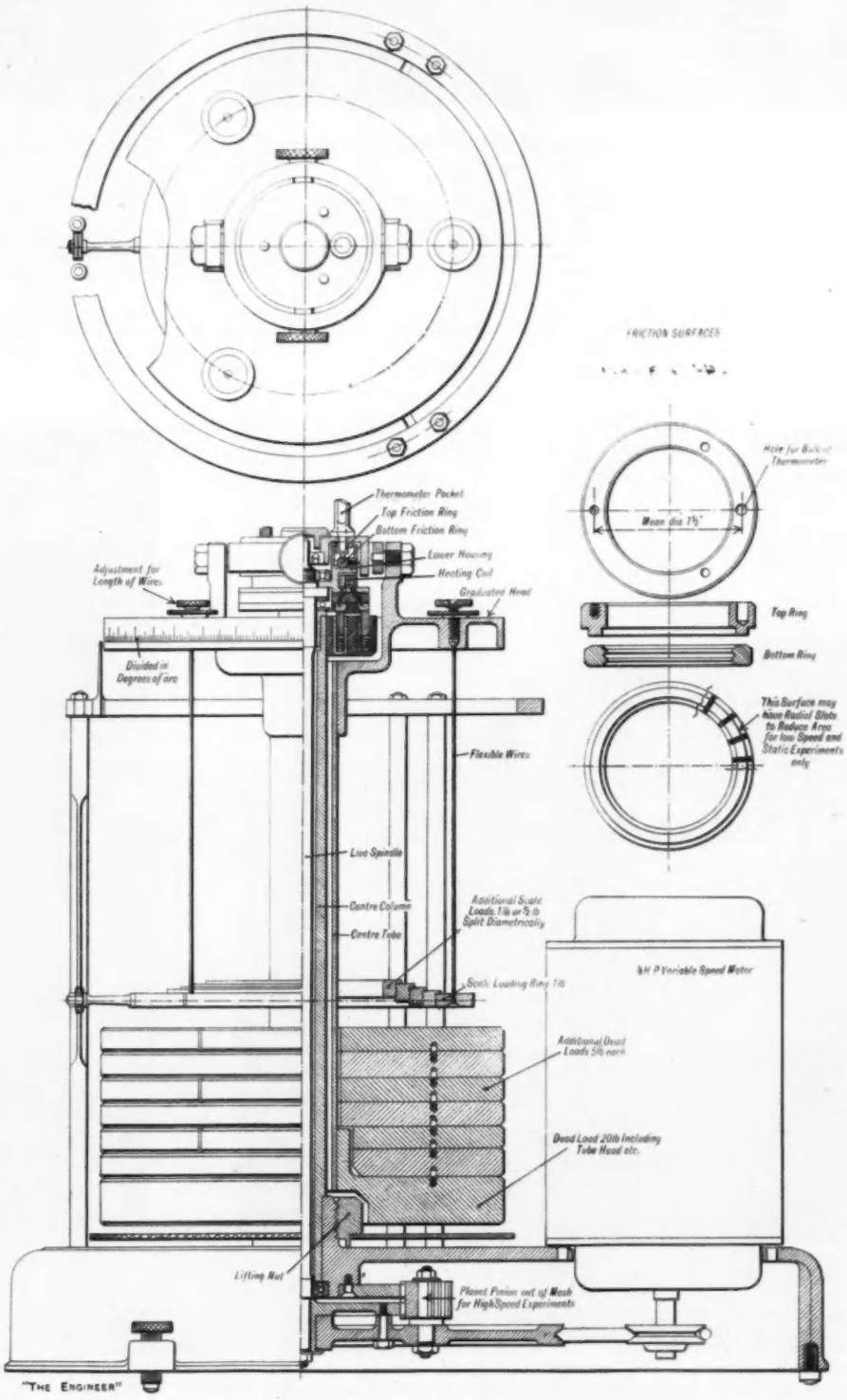

FRICTION SURFACES
Hole for Bulb of Thermometer
Mean dia 1¼"
Top Ring
Bottom Ring
This Surface may have Radial Slots to Reduce Area for low Speed and Static Experiments only
Thermometer Pocket
Top Friction Ring
Bottom Friction Ring
Lower Housing
Heating Coil
Graduated Head
Adjustment for Length of Wires
Divided in Degrees of arc
Flexible Wires
Live Spindle
Centre Column
Centre Tube
Additional Static Loads 1lb or ½ lb Split Diametrically
Static Loading Ring 1lb
¼H P Variable Speed Motor
Additional Dead Loads 5lb each
Dead Load 20lb including Tube Head etc.
Lifting Nut
Planet Pinion out of Mesh for High Speed Experiments
"THE ENGINEER"

FIG. 1—TESTING MACHINE FOR BOUNDARY FRICTION AT VARIABLE SPEED, TEMPERATURE AND LOAD

in a housing carrying a small self-aligning ball race, the bore of which is a light fit on an extension of the live spindle.

The upper housing is attached through gimbals

to two vertical pillars of the graduated head, which carries a tube co-axial with the centre column and enveloping it. This tube is loaded at its lower end by a circular casting, which may be loaded further by the addition of circular weights split diametrically.

As there is clearance at all points between the outer tube and the column, the load is free to hang vertically from the gimbals, and the upper surface beds on the lower one without restraint, ensuring even intensity of bearing pressure over the surfaces, irrespective of small errors in horizontal setting of the plane of rotation of the lower surface.

A circular weighted ring is suspended from the main head by three flexible stranded phosphor-bronze wires. This ring carries three radial arms fitted with small ball races, the outer races of which form rollers and run on three vertical guides, restraining the weight from rotation, while permitting its free rise and fall.

The frictional torque exerted on the top ring by rotation of the bottom one is thus balanced by the torque due to the tri-filar suspension of the scale weight, and the angular displacement of the head when the system is in equilibrium is given by a stationary index in conjunction with the graduated head, which is divided into degrees of arc.

If l = free length of the wires,
r = pitch circle radius of the wires,
w = weight of the suspended ring,
θ = angular displacement of the head,

it follows, without approximation, that the torque T is given by—

$$T = \frac{w\,r^2 \sin\theta}{\sqrt{l^2 - 2\,r^2\,(1 - \cos\theta)}}.$$

This holds good up to the point at which the wires are interfered with by the central tube. On the machine described, $l = 6\frac{1}{4}$in. and $r = 3$in., for which values the maximum torque, which occurs when θ = about 120 deg., is 2·67 foot-pounds per pound weight suspended by the wires. Additional weights of 1 lb. and $\frac{1}{2}$ lb. may be added in the form of split rings, to bring the readings into any desired range on the scale.

In this method of measuring, the torque does not give rise to any radial force, the ball race locating the housing of the top friction surface is virtually unloaded, and its friction is therefore assumed to be negligible, as is that of the rollers on the scale weight, since it is estimated that, assuming that their coefficient of friction is 0·001, they introduce a maximum error of about 0·06 of 1 per cent. of the measured torque. A potential source of error is the stretching of the wires with increase of tension.

Means are provided for heating the surfaces and the oil—to maintain a constant temperature in comparative tests—by winding resistance wire in a circumferential slot in the bottom housing, current being led in by a pair of brushes in a mounting fixed to the spindle column. The leads are wrapped to the centre column and led through drill holes in the boss at the base.

The temperature is indicated by a specially calibrated thermometer, with a small round bulb inserted into a hole in the upper friction surface. Two ranges of speed are provided, in conjunction with a series wound motor capable of wide speed variation.

Direct drive is effected through pulleys, with an 8 : 1 reduction, and a further reduction is given for low speed tests by engaging a differential sun and planet gear, the two sun wheels having 100 and 102 teeth respectively, one fixed and the other driving, in mesh with a pair of planet pinions diametrically opposite, and when these are in mesh the locking bolts are removed. This gives an overall gear ratio of 400 : 1 approximately.

The range of dead load is from 20 lb. to 50 lb., to which, in calculating the coefficient, is added the weight suspended from the wires, up to 5 lb. The load is eased on and off the friction surfaces by a nut working on a thread on the boss at the base of the column, the nut being dropped clear when the machine is in operation. Levelling screws and a bubble on the base plate provide means of setting the spindle vertical.

In making a test the annulus in which the bottom friction surface is arranged is filled with the oil under test, the upper surface in its housing is dropped on, the gimbal pins engaged and the motor started up while the load is gradually applied. Weights are added to the suspended ring until the reading comes on to any convenient range on the divided head, and observations are taken only after steady conditions obtain.

Results of the Experiments.

(1) *Variables.*—After some preliminary work had been done, it was found that the variables to be considered and as far as possible controlled were :—

(1) The material of the friction surfaces.
(2) The lubricant.
(3) The surface "finish."
(4) The time factor in regard to latent periods.
(5) Rubbing speed.
(6) Intensity of pressure.
(7) Ratio of the area of the surface to the perimeter.
(8) Contact surface, continuous or interrupted by oil grooves.
(9) Temperature.

The coefficient of friction is taken as the independent variable.

With the exception of (3), the surface finish, all the variables are easily controlled. Since in these experiments the aim was to exclude the fluid oil film, the surfaces are in intimate contact, and the roughness of the surface affects the friction profoundly, as will be noted later. Before running a test, the rings and their housings were washed in petrol. The abrasive used in the subsequent lapping up was removed by again washing in petrol and rubbing on hard blotting paper. They were deemed to be clean when they were readily wetted by water. The surfaces were originally lapped optically plane, and in use were relapped after each test with Diamative on a true surface plate. For low-speed experiments, cast iron surfaces were used.

(2) *Low-speed Experiments.*—Tests at a steady rubbing speed of the order of 1in. per minute and under pressures from 20 lb. to 750 lb. per square inch, immediately divided oils into two classes for a given state of surface, namely, those which gave a dead beat reading, which could be maintained indefinitely, and those which, by no endeavour, could be made to give a reading other than static.

The former of the two types is broadly represented by the fixed oils, compounded mineral oils, and mineral oils containing a small percentage of free

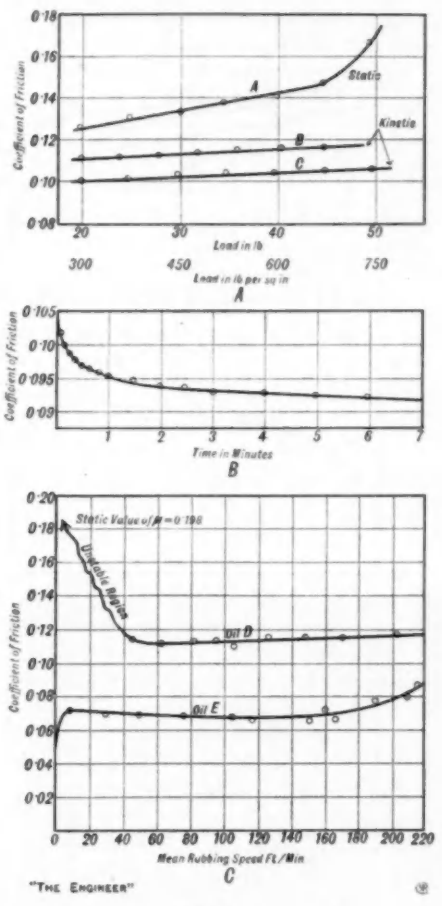


FIG. 2

fatty acid, and the latter by highly refined mineral oils. The viscosity of the oil has little to do with the class into which it falls, judged in this way.

For convenience, they are here referred to as the "oily" and "dry" classes.

Considering an oil on the border line of its class, its behaviour may be of the one type or the other, according to the "finish" of the surfaces. With the surfaces optically flat and highly polished, the steady motion is difficult to attain. The friction is generally high and rises with increase of load. Slight roughness of the surfaces, while still maintaining their overall flatness, aids the attainment of steady motion up to a certain degree. Thus, a given oil will alternately stick and slip with surfaces of highly polished cast iron, will become slightly steadier when the surfaces are finished on Hubert's No. 00 emery, and finally give a steady reading on No. 0. The sticking effect is considered to be due to adhesion, consequent upon the surfaces coming within the effective range of each other's free surface energy, and its absence with certain oils is explained on Langmuir's theory as due to the free surface energy being reduced by the boundary film, those oils which contain strongly adsorbed polar molecules being the most effective in reducing the attraction.

Diagram A, Fig. 2, shows the coefficient of friction plotted against intensity of load for three motor oils. A is a highly refined straight mineral oil and is typical of the "dry" class ; B is the same oil to which 0·75 per cent. oleic acid has been added, and hence their viscosities are identical ; C is a common oil of approximately the same viscosity—*i.e.*, 170 sec. Redwood at 140 deg. Fah. Oil A could not be made to give a steady kinetic reading, and therefore the coefficients plotted for it are static ; B tended to be unstable, the upper bearing surface oscillating with an amplitude of about 2 deg.; and C gave dead beat readings. The surfaces were cast iron finished on No. 00 emery, and the rubbing speed was 0·8in. per minute. In taking static readings the bottom surface is rotated at about $\frac{1}{4}$ r.p.m., and the scale reading observed at the point when slip occurs.

There was no difference in the static or low speed kinetic readings as between continuous surfaces and surfaces in which many radial oil grooves, of square cross section, were cut.

If it is attempted to take static readings on a very oily oil, it is observed that the point of slip is indefinite. Thus, let the surfaces be loaded and the torque be zero, the motor is started and the bottom surface slowly rotated at, say, $\frac{1}{4}$ r.p.m. The top surface is carried round under a steadily increasing torque, but there is no sudden slip at limiting torque, and instead the relative motion between the two surfaces starts imperceptibly and the scale reading creeps up to a steady maximum. With the system in equilibrium, which implies that the upper surface is stationary, let motion of the lower one be suddenly stopped, then, with "oily" oils, the surfaces do not stick, but slide back, showing a slowly diminishing coefficient of friction which reaches a steady value considerably below that of the normal kinetic coefficient. The effect is shown in Diagram B, Fig. 2, where μ is plotted against time. Here the surfaces were cast iron on cast iron, the temperature about 20 deg. Cent., the intensity of load 750 lb. per square inch, and rubbing speed at zero time 1in. per minute.

It was thought that this effect might be due to the kinetic friction falling with regard to speed, as the speed tended towards zero, but even at a speed of $\frac{1}{4}$in. per minute, the friction was observed to fall on arresting the motion. The behaviour to all intents and purposes is as if the surfaces were parted by a thick film of ultra high viscosity, and that, when the bottom surface is stopped, the top one gradually sinks through the film, and, at the same time, is slowly rotated by the applied torque against the viscous friction, until such time as the top surface touches the bottom one. This is offered as an analogue rather than an explanation.

(3) *Variable-speed Experiments.*—It is generally stated that the coefficient of kinetic boundary friction is independent of speed and load, and an attempt was made to find over what range this fact applies. The maximum speed was limited to about 450 r.p.m.—180ft. per minute—by the oil flying out of the annulus under centrifugal force. It was found that, with the radially slotted friction surface, a fluid film was to some extent entrapped between the surfaces and introduced an element of fluid lubrication. The following notes refer, therefore, only to rings whose surfaces were dead flat and uninterrupted.

Taking an oil of the "dry" type, which would not give a steady low speed kinetic reading, it was found that a deadbeat reading became possible above a certain critical speed. Oily oils gave a deadbeat reading at all speeds from $\frac{1}{4}$ r.p.m. up to the maximum possible, but in neither case was the coefficient necessarily independent of speed.

Diagram C, Fig. 2, shows the coefficient of friction plotted against speed, at a constant load of 110 lb. per square inch and temperature of 60 deg. Cent. Oil D is a pale mineral oil of absolute viscosity 0·111 at 60 deg. Cent., and E is the same oil plus 1·25 per cent. oleic acid.

Prior to the tests, the surfaces, the upper of which was case-hardened steel and the lower a special bronze called "Poro," were lapped to a polished finish on a surface plate, and were run in at 175ft. per minute until the friction had dropped to a steady value. Each run was begun at the highest speed, and the speed gradually reduced to zero, keeping the temperature constant by the electric heating device. In Diagram C, oil D shows a critical point at about 45ft. per minute, and at speeds below this there was an unstable state of lubrication, typical of the behaviour of oils of the "dry" class with regard to speed. At zero speed, the friction is assumed to rise to 0·198, the value given by a static test immediately following.

With oil E a deadbeat reading was obtained right down to the lowest possible speed, but the coefficient dropped as the speed approached zero. It should be noted that the values at zero speed for both oils are not normal, and that they were taken without parting the surfaces after running in. In the case of oil D, the friction is considerably higher, and with oil E lower than the normal values.

It appears, therefore, that the shearing of the boundary film at high speed has altered either its normal thickness or the orientation of its molecules. This will be noted below.

(4) *Variable Load Test.*—Diagram D, Fig. 3, shows μ plotted against load for oils D and E at a constant speed of 175ft. per minute and temperature of 100 deg. Cent. Metals, case hardened steel on "Poro" bronze. That μ is found to be substantially independent of intensity of pressure is an indication that true boundary friction obtained under these conditions, according to Amonton's Law, and that no fluid film was present.

It will be observed that the coefficients are lower

than those normally cited, which is due to the elevated temperature.

(5) *Variable Temperature Test.*—Temperature was found to have a profound effect on the friction at high speeds. Unfortunately, owing to the heat generated by the friction, steady observations could not be taken at low temperatures. Approximate readings taken when the machine was started from cold indicated that at normal atmospheric temperatures the coefficient of friction at speeds over about 10ft. per minute may be greater than at very low speeds or than the static value.

Diagram E, Fig. 3, shows μ plotted against temperature and viscosity for oils D and E, under the same conditions as above. It is open to argument whether the change in friction is due to change of temperature *quâ* temperature, or whether it is due to the consequent change of viscosity of the oil, which is the same for both oils. In this connection some experiments made under semi-fluid conditions seem relevant.

(6) *Experiments under Semi-fluid Conditions.*—Here the lower surface was truly flat, but the upper one had three depressions in it, obtained by tightening up the three screws which hold the upper friction ring in its housing, thus distorting the face of the ring from the true plane. The materials were cast iron on cast iron, the bearing pressure 102 lb., and the rubbing speed 117ft. per minute.

The depressions were estimated by pressing a flat glass ring against the surface and observing the interference bands. The area left by these depressions was about 25 per cent. of the total bearing area when not under load. The curves of μ against temperature for oils D and E under these conditions are shown in Diagram G, Fig. 3, and are seen to be totally different from those in Diagram E. The fall of μ with increase of temperature and its low initial value in this case is evidently due to the consequent decrease of viscosity of a fluid film entrapped in the depressions. The critical point might be explained as that at which the fluid pressure is insufficient to support the load and the surfaces come into closer boundary contact. This was confirmed by the observation that increase of load or decrease of speed moved the critical point to the left. It will be seen from the same curve for oil E that the effect of the addition of 1·25 per cent. oleic acid was to raise the critical point with regard to temperature. The foregoing observations on semi-fluid friction are thought to be relevant to the curves of efficiency against temperature on the Daimler Lanchester gear, reported by the Department of Scientific and Industrial Research.

(7) *Time Lag of Static Friction.*—If, at the end of a run at high speed, a static test is made, the surfaces being left undisturbed and the load being maintained, a well-defined latent period may be observed. This is a period of rising friction and may take several hours to attain its maximum value, which is abnormally high. The effect is shown plotted for oil D in Diagram F, Fig. 3. The time taken is the period elapsed with the surfaces under load and at rest since the boundary film was last disturbed by relative motion of the two surfaces under load, at "high speed."

The test was conducted by running the machine at any chosen speed until minimum friction was registered, both the surfaces being truly plane. It was then stopped, the low-speed gear engaged, and the machine left undisturbed, a static test being taken after the desired interval of time. The process was repeated at varying intervals of time for each point on the curve.

If the surfaces be parted and allowed a few minutes' rest, so that free access of oil is allowed, and a static test is then taken, it is found that the friction will then have attained its maximum value, which it took several hours to reach when the surfaces were continuously under load.

The effect was observable with all oils, but most readily with the "dry" class, and it escaped notice, except after the surfaces had been well bedded down by running at high speed.

General Conclusions.

With regard to the low-speed and static experiments, the effect of adhesion between flat polished surfaces is well known, but that minimum friction was given by the "finish" left by No. 0 emery is worth noting as it was distinctly rough in comparison with a polished surface. On such experiments as were carried out with white metal—Hoyt No. 11—a very high coefficient of static friction was given, probably owing to the plasticity of the metal permitting intimate contact.

From the low-speed kinetic results, it is deduced that many oils in common use only permit, using Hardy's terminology, a primary boundary film under loads as low as 40 lb. per square inch, and that the "oily" class of lubricants give a stable secondary film, even under pressures up to 750 lb. per square inch.

The phenomenon of decreasing friction—Diagram B—consequent on stopping the slow rotation of the lower—driven—surface, is submitted as an observed fact without offering an explanation.

From the high-speed tests it is deduced that given a suitable oil and bearing material, stable boundary lubrication can exist at least up to speeds of 180ft per minute, pressures of 260 lb. per square inch, and temperatures of 100 deg. Cent.; that over a wide range of pressures and speed it follows Amonton's Law, in that the coefficient of friction is independent of intensity of pressure, and of speed; but that there is a lower limit with regard to speed which depends at least on the oil, the load, and the nature of the surfaces. The boundary friction at high speeds was also found to be profoundly reduced by increase of temperature, and for any two oils of the same viscosity by "oiliness."

The region of instability shown by dry oils, such as D in Diagram C, and the phenomenon of a latent period of rising static friction in Diagram F, require explanation. Accepting Hardy's view that, *pari passu*, the friction of a boundary film decreases in proportion to its thickness, one can assume that prolonged running at high load and speed shears the film down, beds the surfaces into close contact, and polishes them, the latter favouring high static friction. When rotation ceases, the Leslie pressure begins to lift the surfaces apart, and build up the

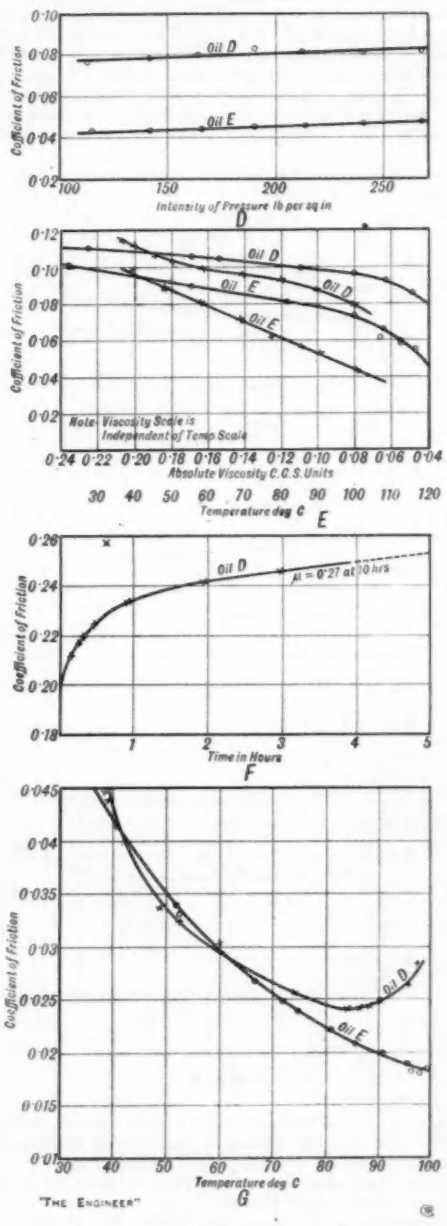


FIG. 3

secondary film, with a consequent rise in friction, and it may be assumed to be the time required for this rebuilding which is the cause of the latent period of rising static friction. That view is in conformity with the fact that the period is very short if the oil is allowed free access to the surfaces by lifting them apart.

The unstable range of speed in the case of "dry" oils—as in Diagram C, oil D—may be explained by assuming that relative motion above a certain minimum speed in some way prevents adhesion.

Further work is required to find out to what extent the values of the coefficients of friction above cited are absolute values for a given combination of bearing metal and lubricant, and they are thought to be dependent to some degree upon the surface finish imposed on the metal at the start or acquired by it in the source of running. It is also required to corelate with bearing pressure the effects shown in Diagrams B and G.

The writer's thanks are due to the Henry Wells Oil Company, Ltd., 11, Haymarket, S.W. 1, for permission to publish the foregoing.

The Standardisation of Keys and Keyways.*

By WILLIAM REAVELL, Past-president.

No apology is needed for introducing to the Institution a paper on this subject, for under this general title are grouped all the methods of keying or otherwise securing two separate members together, or providing for relative movement axially, and these are matters with which the mechanical engineer has to deal in his every-day work.

Moreover, the author ventures to think that it may be of interest to relate something of the inner history of standardisation under the British Engineering Standards Association. No one who has not been engaged upon such an undertaking—as the author has been for many years—can appreciate fully the enormous amount of work that is entailed. Standardisation is always a compromise in which tradition and "vested interests" have to be persuaded to come into line with the best practice indicated by science. Some give and take is inevitable, and it is only after many months of work that agreement is reached. The voluntary labour given without grudging to this important work is something of which engineers may be justly proud.

The decision to appoint a committee to deal with the standardisation of keys and keyways by the Engineering Standards Committee, now known as the British Engineering Standards Association, was arrived at as a result of a letter, written by the author nearly twenty-four years ago. It touched only the fringe of the subject, but its results have been so far-reaching that it may be quoted:—

Leslie S. Robertson, Esq.,
Engineering Standards Committee,
28, Victoria-street, S.W. 19th December, 1905.

DEAR SIR,—

In connection with our business, where numbers of different types and makes of motors come into our hands for attachment to our air compressors, either for direct coupling or gearing, the question of having a uniform rule for the width and depth of keys has been before us several times.

Different firms have different rules as to the proportions they adopt for keys, but there seems to us no reason in principle why a recognised standard should not be adopted. It would have two advantages:—

(1) Keyways in shafts and in wheels could be safely cut by a machine without waiting for the other part to be received from an outside source, *e.g.*, if we are supplying wheels while a motor maker is supplying a spindle, we could safely finish our work before receiving his, and it would save the expense and loss of time in sending key gauges.

(2) It would then greatly reduce the present relatively high cost of key making, because standard sections could then be rolled, at all events for all flat keys, and, as the material when bright can be produced within 0·001in. or 0·002in. of the standard sizes, very little fitting would be required. The key section could be supplied in the shape of standard keys of standard length, or, what perhaps would be better, standard bars, which should not be too long for fear of irregularity in the length, and could be stocked by hundreds of makers in our position, and cut off, as required.

We should be glad to hear whether you think this matter is not one which might be fitly considered by the Standards Committee.

The Main Committee of the old Engineering Standards Committee considered that standardisation was desirable, and appointed a sub-commitee in 1906, consisting of Colonel R. E. Crompton, C.B., Colonel H. C. L. Holden, R.A. (now Sir Capel Holden, K.C.B.), Mr. T. Clarkson, Mr. Henry Lea, Mr. R. Matthews, Mr. Alfred Herbert (now Sir Alfred Herbert, K.B.E.), Mr. W. Reavell, with power to add to their number.

The importance of obtaining the views of the industries of marine engineering, motor manufacturing and electrical engineering, &c., led to the inclusion of the following names, which then constituted the complete Committee:—Mr. P. Ransom, Mr. T. Donaldson, Mr. H. G. Burford, Mr. J. Schiller, Mr. J. Connor, and Engineer-Commander E. F. Ellis, R.N. (representing the Admiralty). The range of work then contemplated only comprised parallel and taper headless keys.

A questionnaire was drawn up for submission to a large number of users and makers of keys, covering the following matters:—(1) The forms of keys most generally used; (2) the range of shaft sizes manufactured; (3) the proportions for the keys and keyways; (4) the number of key sizes to be standardised; (5) the types of keys to be standardised; (6) the margins of manufacture to be specified on the steel bars from which the keys were to be cut.

From the replies received from the questionnaire a tentative proposal for standard key sections was drawn up and submitted to a number of firms for criticism.

At this stage a considerable difference of opinion among the members of the Sub-committee, and of practice in the country, was manifest on two important points:—(*a*) The depth of the key in relation to its width; and (*b*) the depth of immersion of the key in the shaft. On the first, opinions varied between the extremes of a broad thin key, on the one hand, and a square-section key on the other hand.

Experiments were then carried out by the late Mr. Ransom at the works of the Unbreakable Pulley and Millgearing Company, with the collaboration of Dr. Unwin and Professor Larard, which resulted in the following decisions:—(1) That the width of the key should be one-quarter of the diameter of the shaft; (2) that the depth of the key should be two-thirds of the width; (3) that the immersion of the key in the shaft should be half the depth of the key, measured on the centre line.

Thereupon the Sub-committee completed, and the Engineering Standards Committee published, the first British Standard Specification for Keys and Keyways, No. 46, in September, 1909.

This specification for the first time standardised keys of definite sizes suitable for shafts from 1¼in. up to 12in. diameter, and accurately finished key bars from which keys could be cut off, the key bars being manufactured within a tolerance varying from 0·002in. for the key for the smallest shaft, to 0·005in. for the largest key for the 12in. shaft. The tolerances for the keyways were also determined. By these means key bars could be ordered in

* The Institution of Mechanical Engineers.

considerable lengths, and the keys could be cut off to any required length, with the knowledge that a few strokes of a file would be sufficient to produce a standard key to fit a standard keyway.

After the publication of this specification, it became clear that amongst well-known engineers there was still some doubt that the Committee's standard key satisfied all conditions in practice, particularly in the case of reversing stresses thrown upon a key. Furthermore, the question of standardising other forms of keys in addition

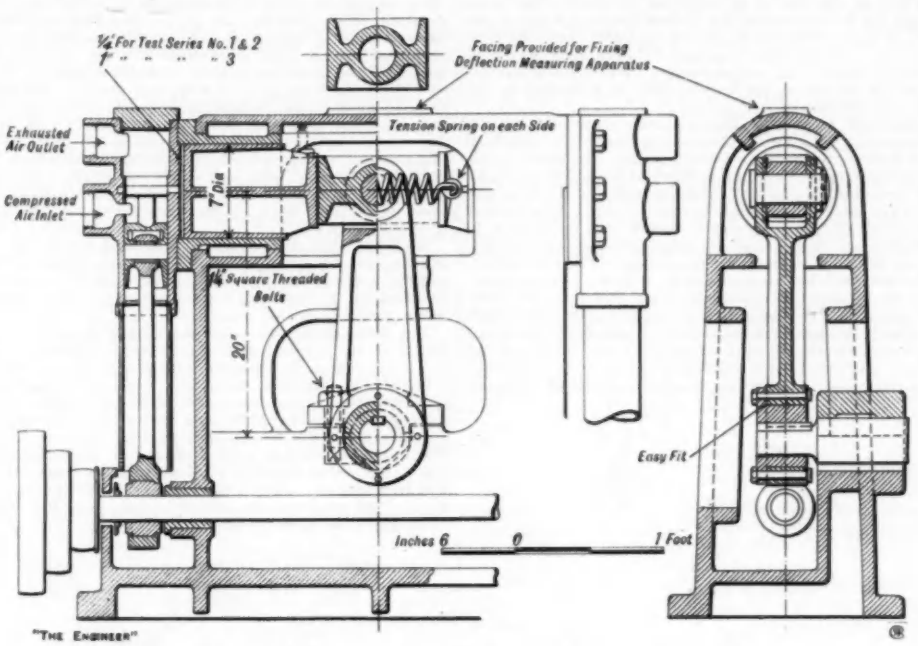


FIG. 1—KEY-TESTING MACHINE FOR REVERSAL STRESSING

demanded consideration. The problem was referred to the Main Committee in a report, with the result that the Sub-committee was authorised to investigate more fully the work thrown upon a key when subjected to alternating stresses. Various designs of machines were considered, and finally the design of a pneumatic testing machine was approved, and this machine was manufactured by Messrs. Reavell and Co., in readiness for tests to be carried out at the National Physical Laboratory.

Fig. 1 shows the construction of this machine. The specimen shafts to carry the keys were 2¼in. diameter. To ensure perfectly sound material, they were forged down and turned from a 4in. diameter shaft. They were securely clamped between the cap and base of the machine, as shown. The hub to carry the key was formed of a cast iron ring having a flange by means of which it could be bolted to a long cast iron arm provided with a jaw at its other extremity. In this jaw a crosshead was fitted, and secured to the arm by a pin. The ends of the crosshead were faced to bear against two pistons arranged to supply pressure alternately to each side of the crosshead. The two pistons were linked together by a pair of springs. In the base of the machine, carried in bearings, was a shaft provided at one end with a stepped cone pulley, so designed that speeds up to 500 r.p.m. could be obtained. On this shaft were keyed two excentrics operating piston valves, one at each end of the cylinder, so that air pressure could be applied to one piston or the other alternately at any required speed up to the maximum, which would give 1000 reversals of stress on the key per minute.

At this stage it was determined to test the relative values of square keys and rectangular keys. Following the rule that the key should have a width one-quarter of that of the shaft diameter, the keys were ⅝in. wide, the rectangular keys being ⅜in. deep and the square keys ⅝in. deep. The alternating torque which could be applied to the key was very simply regulated by varying the air pressure, and the maximum torque attainable was as high as 65,000 pound-inches.

Fig. 2 shows the machine as arranged for the tests, and it will be seen that a recording gear was fitted to it in order (1) to measure the relative movement between the hub and the free end of the shaft; (2) to draw a record giving the movement of the top end of the rocking lever; and (3) to give a record of the air pressure on the piston attached to the lever on the crosshead. During 1913 and 1914 tests were carried out at the National Physical Laboratory. The mechanical tests on the materials gave the following results:—

Tensile Test.

	Mild steel shaft.	Key steel.
Yield stress, tons per square inch	11·8	24·9
Ultimate stress, tons per square inch	25·6	33·6
Extension, per cent.*	44·2	21·3

* Test piece 0·625in. × 0·438in.; gauge length, 6in.

Ball Hardness Test.

10 mm. ball, 3000 kilos.

	Hardness No.
Cast iron	344
Mild steel shafts	161–186
Forged steel shafts	192–265

Compression Test.

Crushing stress of cast iron = 58·4 tons per square inch

In making a test the air pressure in the cylinders was regulated to give an alternating torque on the shaft of given amount. After a certain number of alternations, 5000 or more, the torque was increased by a definite quantity and the process repeated. It was found that, except with torques of 45,000 pound-inches and over, there was very little alteration of the movement recorded after the first 100 alternations. The combination ultimately failed by the shaft seizing in the hub—owing to the heating of the shaft—and consequent shearing of the shaft.

The results appeared to indicate that with the mild steel the deep key was preferable, whilst on the forged steel the results were reversed. There was, however, so little difference between the two that no definite conclusion as to relative merit could be drawn. It was apparent that the smaller of the two keys was amply strong with mild or forged steel when used on an overhung shaft.

Careful measurements of the keys and keyways before and after the test showed that practically all the deformation took place in the keyway in the shaft, and, further, that, as would be expected, the greater part of this deformation took place near the fixed end of the shaft where the elastic displacement was necessarily least.

On the outbreak of the war no further meetings of the Sub-committee were held, but the work was resumed in November, 1922, the Engineering Standards Committee having, in the meantime, become the British Engineering Standards Association. In accordance with the policy of the Association, the Sub-committee was reconstituted to include every interest which could be concerned in the more ambitious programme upon which it had decided to embark.

The previous work of the Sub-committee was reviewed, and, as the information given by the first series of tests was not considered conclusive, a further series was carried out at the National Physical Laboratory, with the same pneumatic testing machine, on steel shafts of higher tensile strength. The material used for the purpose of these tests was:—(1) A bar of steel having an ultimate tensile strength of 32 tons per square inch; and (2) a bar of steel having an ultimate tensile strength of 44 tons per square inch. The sizes of the keys used were the same as those in the first series of tests, namely, ⅝in. wide by ⅜in. deep and ¼in. wide by ⅛in. deep.

The method of keying the hub to the shaft and of carrying out the tests was precisely the same as that adopted in the first series, with the exception that as the maximum torque to which shafts of this size are supposed to be liable was of the order of 20,000 pound-inches, it was thought advisable to confine the torques applied during the test to values within this limit, and to repeat them for a much greater number of times. The programme on each combination of shaft, hub, and key has accordingly been as follows:—

Alternating torque, pound-inches.	Number of alternations.	Alternations per minute.
5,000	500,000	100
10,000	100,000	100
15,000	100,000	100
20,000	500,000	100

The results of the tests are summarised in the accompanying table:—

Results of Tests with Steel Shafts of Higher Tensile Strength.

Test No.	Material of shaft, tons per sq. in.	Brinell hardness No. of shaft.	Dimensions of key, in.	Angular movement of lever in radians at end of period, at torque of— 5,000 lb.-in.	10,000 lb.-in.	15,000 lb.-in.	20,000 lb.-in.
9	32	142	⅝ × 7/16	0·00015	0·0003	0·0006	0·0031
10	32	142	⅝ × 7/16	Nil	—	—	Nil or 0·0044*
13†	32	142	⅝ × ⅜	Less than 0·0001	0·0009	0·0016	0·0020
11	44	206	⅝ × 7/16	0·00015	0·0010	0·0016	0·0023
12	44	202	⅝ × ⅜	Nil	Nil	Nil	0·0028

NOTE.—A movement of 0·01in. at the surface of the shaft is equal to an angular movement of 0·008 radians.

* Unsatisfactory test.
† Repeat of No. 10.

It will be seen that the material of the shafts from the same bars gives hardness numbers in very good agreement.

The results of tests Nos. 9, 10, 11 and 12 show that up to a torque of 15,000 pound-inches, the larger key—test No. 12—is superior to the smaller one, in that no movement could be detected, but at torques of 20,000 pound-inches the behaviour of the two keys were much the same. Unfortunately, this conclusion is not borne out by the results of test No. 13, which was a repetition of test No. 10. A careful examination of the dimensions of the hub, shaft, key and keyway before the test appeared to indicate that it was the slight taper of the hub—0·002in.—in the direction most favourable to the movement which was probably responsible for the movement at low torques which was observed. The fact that in test No. 10 no movement at low torques was recorded can also be ascribed to the good fit of the shaft and hub at the small end of the key. The results confirm the conclusions from the first series, that the ⅝in. by ⅜in. key is amply strong for a 2¼in. shaft when using shaft material of an ultimate strength up to 44 tons per square inch.

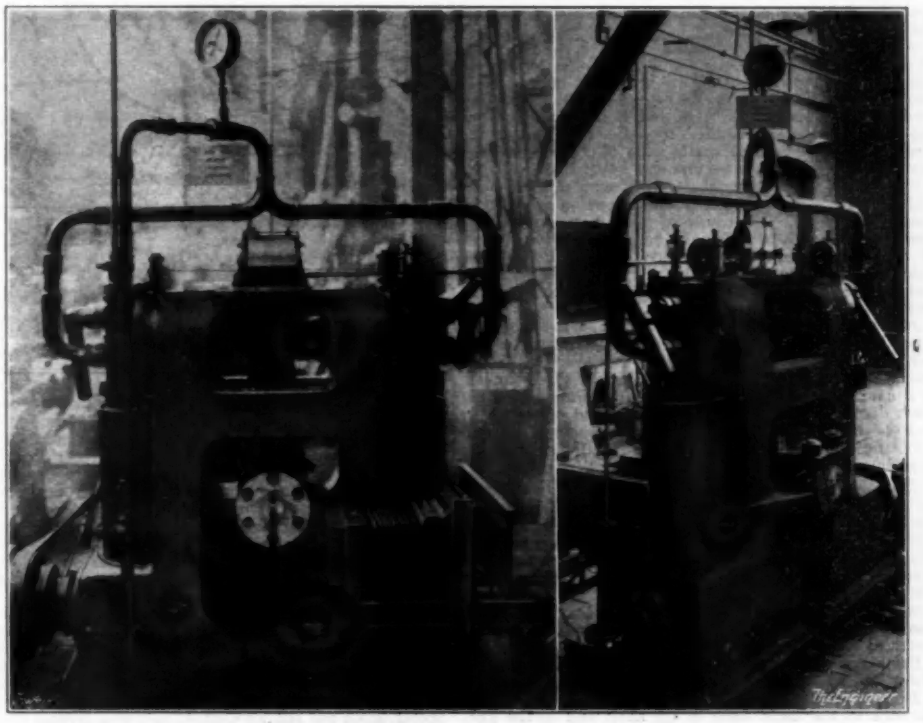


FIG. 2—KEY-TESTING MACHINE ARRRANGED FOR TESTS

The specification No. 46 was reviewed in the light of the experience gained since its issue in 1909, and it was decided that the issue as to the rectangular *versus* the square key would best be solved by issuing separate tables for each, so that users would have the choice of two standardised keys for any shaft diameter. Tables were, therefore, prepared for the following:—Rectangular parallel keys; square parallel keys; rectangular taper keys; square taper keys.

The tolerances for standard key bars for these were also determined, and the taper keys of each class were so proportioned that the same key bar would serve. Keys for shafts from ¼in. up to 12in. diameter were provided for. In every case the key can be cut off from the finished

bar, and by a few strokes of the file can be fitted into the standard keyway.

The rectangular key has still a width nominally one-quarter of that of the shaft diameter, and a depth two-thirds of its width.

Regarding immersion of the key in the shaft, it has been found more convenient for shop practice to make the immersion of the key half its depth at the sides of the key instead of on the centre line.

The amended table of plain rectangular keys, and the new table of plain square keys were published in 1924, as British Standard Specification No. 46, Part I. Taper keys, however, appear for the first time in the British Standard Specification No. 46, 1929.

Gib-headed Keys.—The next work undertaken was to standardise gib-heads for rectangular and square taper keys. The key itself is the same in section and taper as the corresponding plain taper keys, so as to ensure similarity in keyways. The opinions of makers and users throughout the country were sought as to the precise form of the gib-head, and on the results so obtained gib-heads—regarding which inquiries showed that there had been a great diversity of practice—were, for the first time, standardised. These keys appear in the present specification No. 46, 1929.

In determining the dimensions of the gib-heads, the Sub-committee had to take into consideration (1) whether the heads should have a bevel or a radius; (2) whether the inner face of the head should make a right angle with the lower face of the key or whether it should make an acute angle; and (3) whether the line of contact of the head with the upper face of the key should have a radius.

It was decided that the heads should have a 45 deg. bevel; that the inner face of the head should be at right angles to the lower face of the key, and that a small radius should be shown at the junction of the gib-head with the key.

The dimensions for the gib-heads were based on the following proportions:—

Width of head = width of key, plus $\frac{1}{16}$in.
Projection of head above upper face of key = half width of key, plus $\frac{1}{16}$in.

The length of the key is measured from the end of the key to the inner face of the gib-head.

Peg Feather Keys.—This type of key is of square section and is largely used in the construction of machine tools, *e.g.*, in the keyway of drilling machine spindles and for feed shafts of lathes, and permits relative axial movement between the shaft and a hub or other member of the pair. The peg can be round or square, and may be placed at the centre or at one end of the key. The peg feather key sections correspond with the standard square parallel keys, enabling the same keyways to be used for both types of key. The standard depth of the peg has been made equal to the thickness of the key. In cases where it is desired to rivet the peg of the key to the fixed or sliding member, a suitable increase in the length of the peg must be provided.

Coned and Keyed Shaft Ends.—The Sub-committee then investigated the question of keys fitted on coned shafts, and found a diversity of practice. Three points arose in considering these, namely—(1) the standard taper to be adopted; (2) the relation the key should bear to the standard rectangular and square keys for a given shaft diameter; and (3) whether the key should be fitted parallel to the axis of the shaft or parallel to the side of the cone.

As regards the taper, existing practice showed that, whilst 1 in 10 on the diameter was more common for general engineering practice, 1 in 12 was the usual marine practice. It was agreed to have a couple of ground samples made having tapers of 1 in 10 and 1 in 12, and to test the amount of effort required to force the hubs off the shaft ends. The sample shafts were 6in. diameter, and the length of the hubs were one and a-half times the diameter of the shaft. The shaft ends were of mild steel, and the hubs of cast iron, and were forced on at ordinary shop temperature. The result of these tests showed that there was very little difference between the two tapers as regards the pressure required to remove the hubs after being drawn on to the shafts by means of an equal and known leverage applied to the nuts on the screwed ends of the shafts.

It was decided to recommend (1) that the standard taper be 1 in 10 on the diameter; (2) that the key be parallel to the side of the cone; (3) that the keys should conform to the dimensions of the standard rectangular or square keys, the size of the key corresponding with the shaft diameter equivalent to the larger end of the cone; and (4) that the key should not be shorter than one and a-half times the diameter of the shaft at the large end of the cone.

Tangential Keys.—This form of keying is chiefly used for heavy electrical machinery, rolling mills, &c., where the load is intermittent and periodically reversed. Twenty-three firms were asked for particulars of their practice. From the returns received it appeared that the practice varied so much that there was no common basis for the standard dimensions for these keys. At the same time, it was felt that this was a very useful type of key, which was likely to come into more general use if a table of standard dimensions was available.

Proposals for two types of tangential keys were then drawn up, as shown in Fig. 3.

In each type the keyways are machined parallel with the axis of the shaft, both in the shaft and in the hub. The keys are also parallel on three sides, but the sides of the key which come into contact with each other have a taper amounting to 1 in 100, thus forming a pair of folding keys. The wedge action of this taper tends to tighten the parallel sides of the key against both the hub and shaft, thus ensuring a very tight fit on the driving edges of both keys, which is a matter of great importance in cases where, owing to heavy reversing drives, it is found necessary to fit two keys in one shaft.

It will further be noted that in type A design the widths and the thicknesses of the keys are mathematically fixed in relation to each other. The width W of the two parts forming the key is three-tenths the diameter of the shaft, and the thickness T necessarily follows as one-tenth of the diameter of the shaft. The alternative type of tangent keying, type B, which gives the same wedging action when driven tight, may be preferred as regards the machining, as both keyways in the shaft or hub can be cut at one operation.

In the case of type A, it will be obvious that, owing to the fact that diagonally opposite points of the key section must be on the circumference of the shaft, a key of different width and thickness would theoretically be necessary for every change in shaft diameter, however small. In type B, on the other hand, a key of given width and thickness is used for any intermediate shaft diameters between defined ranges.

The length of the keys is determined by the length of the hole in the part to be keyed on the shaft. The extra length for driving should not be less than the width of the pair of keys. Gib-heads should be used when the keys can only be driven from one end. If both ends are accessible, gib-heads are not necessary. When gib-heads are used, the length of the keys should be measured to the inside of the heads.

Woodruff Keys and Keyways.—In 1920 the British Engineering Standards Association issued a standard specification for milling cutters, which included a table of dimensions for cutters producing Woodruff keyways, but no authoritative table of dimensions for the keys and keyways has been available in this country. This form of key being of American origin, endeavours were made to obtain from America some information as to the true source of the Woodruff key dimensions. The information obtained may be summarised as follows:—It appeared that Mr. William N. Woodruff, of the Pratt and Whitney Company, was the originator of this key some forty years ago, and the keys were subsequently manufactured by the Whitney Manufacturing Company. The selection of the sizes of keys suitable for different diameters of shafts was a matter which engineers generally preferred to settle

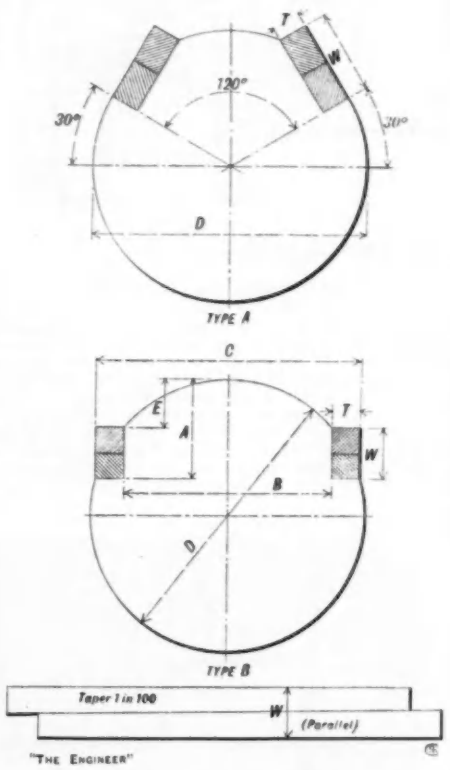


FIG. 3—TANGENTIAL KEYS

for themselves. The keys were used in such large quantities in the manufacture of automobiles and all other classes of high-grade machinery that engineers were thoroughly familiar with their use and seldom sought information as to how to use them. There is a large variety of combinations of diameters and thicknesses of these keys which gives the engineer a wide range of choice in the selection of a key for any particular purpose. Two or more keys can be placed end to end if the length of one key is not sufficient. The operations of cutting a key seat for Woodruff keys and fitting the key do not require highly skilled labour. The Woodruff key reaching deeper into the shaft than one of ordinary construction, it is more firmly embedded, and hence is capable of standing a much greater stress. It is impossible for a Woodruff key to roll over in its seat, as is sometimes the case with an ordinary key. The projection of the key above the shaft is equal to one-half its thickness.

The standard table which has been drawn up by the Sub-committee covers key sizes from $\frac{1}{8}$in. to 1$\frac{1}{4}$in. diameter in various thicknesses, the widths and depths of the keyways in the shaft and hubs, and the manufacturing tolerances thereon. The corresponding Woodruff key cutter numbers, as listed in Table XXXI. of the British Standard Specification for Milling Cutters, are also given.

Splines.—Post-war years have seen a rapid growth in the use of splines, or, as they are sometimes termed, castellated shafts, and the Sub-committee proceeded to investigate current practice thoroughly. It was found that variations existed in regard to the number of splines and the amount by which each spline stood out on the shaft. It was further observed that in some cases the practice was growing of using a large number of small splines on a shaft, and the investigation of this led to the use of still smaller splines of a V-shaped form, known as serrations. It was concluded that the present period, when industry was just beginning to use these later forms of attachment, was an ideal time to study and standardise them.

Particulars of these various standards are as follows:—

Four and Six Splines.—Standards for four and six spline shafts and holes, both shallow and deep, have been drawn up, covering shaft diameters from $\frac{1}{8}$in. to 6in. Four classes of fits have been provided, corresponding to "easy sliding," "close sliding," "light driving," and "force" fits. In machine tool and other classes of work a hardened gear is frequently fitted to an unhardened spline shaft, and in such cases it is essential that the fit should be on the minor diameter of the shaft, so that the hardened gear can be readily ground to fit after hardening. The splines are, therefore, bottom fitting, *i.e.*, the fit takes place on the minor diameter of the shaft.

Multiple Splines.—As the increasing use of splines is likely to lead to their being generally adopted for large-diameter shafts, and in view of the fact that the use of large number of splines gives a greater relative strength compared with a solid shaft than the use of fewer but deeper splines, a tentative table of multiple splines, based on eight splines per inch of diameter, covering the same range of shaft diameters and fits as in the case of the four and six-spline standard, has been prepared. The fit in this case takes place on the major diameter of the shaft. The multiple splines are not intended for work which has to be subsequently hardened, and it is probable that their use will be limited to hollow shafts with thin walls and to cases where hubs are of large diameter and at the same time relatively short.

It is felt that this tentative standard will avoid the introduction of a multiplicity of designs by individual makers, and will have the effect of establishing a common standard for general use if the principle of the multiple spline grows in favour.

The indexing of all spline shafts and broached holes should be within such limits that the shaft will enter either end of the hole in any possible engaging position.

Serrations.—Serrated shafts and holes are intended for such purposes as the attachment of levers to shafts where the angular position of the lever may require fine adjustment, and for the attachment of thin hubs to shafts. The standard B.E.S.A. table covers shaft diameters from $\frac{1}{8}$in. to 3in. to the same four classes of fit as those for the standard splines. The fit takes place on the sides of the sides of the serrations, a clearance being provided at the crests and roots of the teeth—Fig. 4.

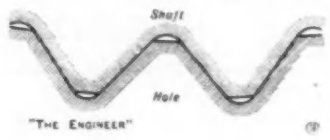


FIG. 4—SERRATIONS

Taper Pins.—The standard taper pins—solid and split—have been designated by their fractional sizes and not by Morse numbers, and the size of the pin is measured by its diameter at the large end. The standard taper is 1 in 48 on the diameter, which is equivalent to $\frac{1}{4}$in. per foot on the diameter. The standard table contains sizes from $\frac{1}{8}$in. to $\frac{1}{8}$in. diameter, in lengths varying from $\frac{1}{2}$in. to 6in. These diameters and lengths are those which makers in general are prepared to supply from stock. Intermediate and larger diameters and pins of greater length, such as those used for locomotive work, are not regarded as stock sizes. Split taper pins are required to be split and not sawn, and the length of the split portion must not be less than 20 per cent. of the length of the pin.

Standards for hand and machine taper pin reamers were issued by the British Engineering Standards Association in 1920.

A standard specification for the material and tests for solid and split taper pins has also been drawn up. The chemical composition has been defined. The finished pins have to show a tensile breaking strength between the limits of 28 and 32 tons per square inch, with an elongation of not less than 25 per cent. measured on a gauge length equal to four times the square root of the area of the test piece. Solid taper pins must permit of being bent cold through an angle of 180 deg. round a circle of diameter equal to the mean diameter of the pin without showing signs of fracture. Split taper pins must permit of being opened up for two-thirds the length of the split, and the wings bent backwards through an angle of 180 deg., and closed upon the pin without showing signs of fracture.

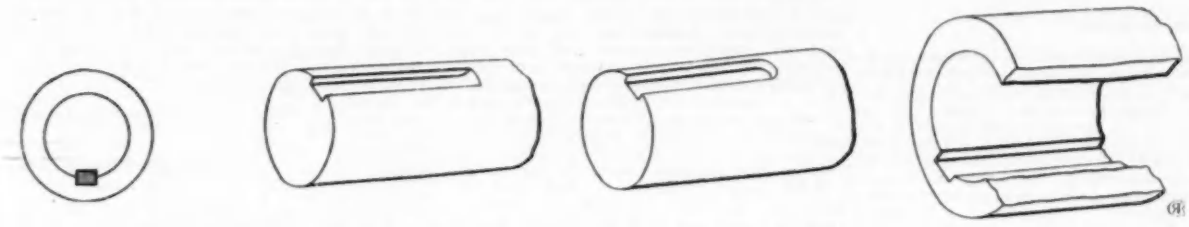
Standard Nomenclature for Keys and Keyways.—In conjunction with the steady work on the new tables of standards which have been dealt with in this paper, the reconstituted Committee has also been investigating the question of nomenclature, because of the diverse names given in various parts of the country to the same form of key.

Definitions of each form of key were fully debated, and in 1925 a letter on the subject was addressed to the technical Press, which very willingly published it. This letter sought for the criticism and comments of engineers generally. As a result, valuable assistance reached the Committee from many sources. The revised nomenclature thus arrived at was next submitted to the principal institutions and engineering associations and societies, and the final nomenclature, with illustrations of each type, is given on page 459.

In conclusion, the author ventures to suggest that the completed specifications now issued form an excellent illustration of the advantages of standardisation for an engineering component so universally used, and it is a matter of some pride to this country that the British Engineering Standards Association should be the first to arrive at and publish such a comprehensive series of standards. For the first time, technical schools and technical colleges and the engineering works of the country will have an agreed standard and a definite nomenclature which should be of advantage to engineering development.

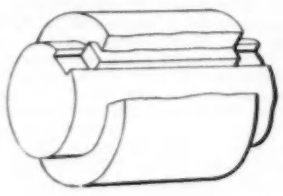
A STEEL strip rolling mill has been put in operation at the Vereinigte Stahlwerke, Aktiengesellschaft Deptmt. August-Thyssen-Hütte, Dinslaken, which is said to be capable of rolling down an ingot measuring 11in. by 3in. by 40in. into strip of 11in. by 0·108in. cross section in 48·5 seconds.

THE NOMENCLATURE OF KEYS AND KEYWAYS

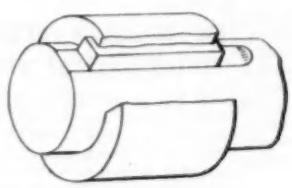


1 AND 2—*Key.*—A key is a piece inserted between the joint of two parts to prevent relative movement. For the purpose of this specification a key is defined as a piece inserted in an axial direction between a shaft and a hub to prevent relative rotation. *Keyway.*—A recess in a shaft or hub to accommodate a key.

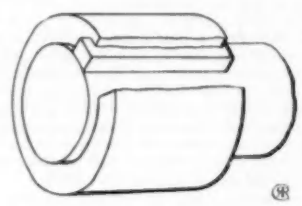
3 TO 7—*Plain Parallel Key.*—A key of rectangular or square section; uniform in thickness and width and with squared ends. *Round-ended Parallel Key.*—A plain parallel key with ends rounded as to width. *Plain Taper Key.*—A key of rectangular or square section uniform in width; tapered in thickness and with squared ends. *Round-ended Taper Key.*—A plain taper key as defined above, but with ends rounded as to width. *Gib-head Key.*—A key provided with a head to facilitate withdrawal.



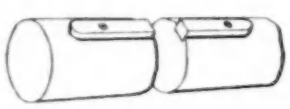
8—*Sunk Keys.*—A key partly in the shaft and partly in the hub.



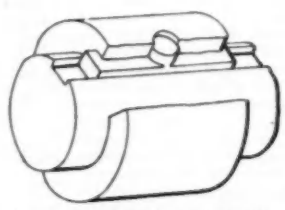
9—*Flat Saddle Key.*—A taper key fitting a keyway in the hub and a flat on the shaft.



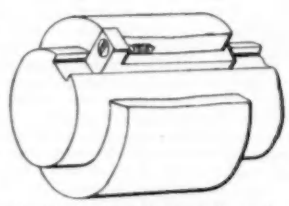
10—*Hollow Saddle Key.*—A taper key fitting a keyway in the hub, the bottom of the key being formed to fit the cylindrical surface of the shaft.



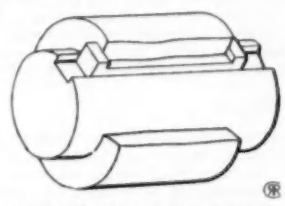
11—*Feather Key.*—A key attached to one member of a pair and permitting relative axial movement.



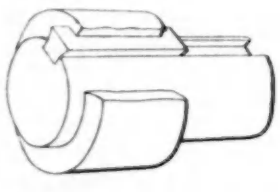
12—*Peg Feather Key.*—A feather key with a peg to prevent its relative movement in the part to which it is attached.



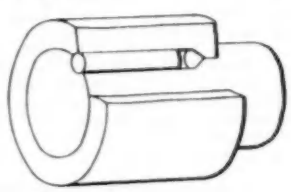
13—*Single Head Feather Key.*—A feather key with a projection at the end to prevent its axial movement in hub.



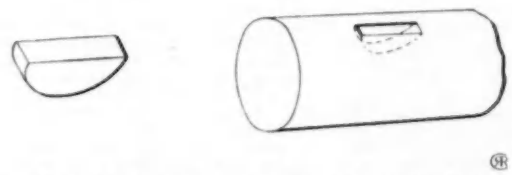
14—*Double Head Feather Key.*—A feather key with a projection at each end to prevent its axial movement in hub.



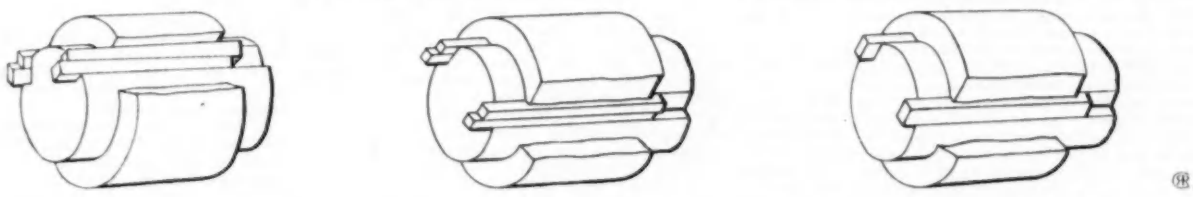
15—*Dovetail Key.*—A key having one portion of its cross section of dovetail form.



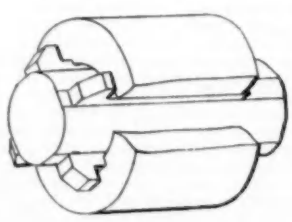
16—*Round Key.*—A key of circular section fitted in a hole drilled partly in the shaft and partly in the hub.



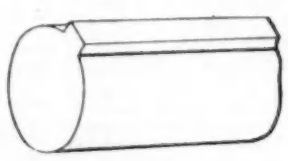
17 AND 18—*Woodruff Key and Keyway.*—A key in the form of a segment of a parallel-sided circular disc and a segmental recess in a shaft to accommodate a Woodruff key.



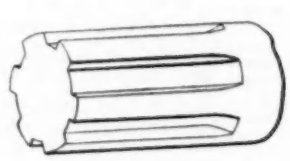
19—*Tangential Keying.*—The use of keys acting tangentially in opposite directions.



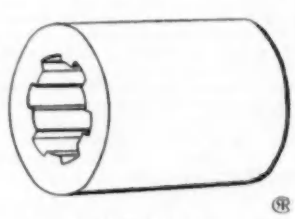
20—*Stake Keying.*—The use of taper keys for centralising the hub on the shaft and for preventing relative movement. They may be hollow or flat saddle keys.



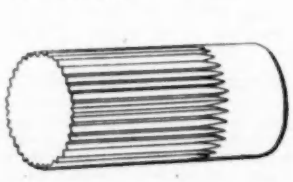
21—*Spline.*—A key-like projection integral with a member of a pair.



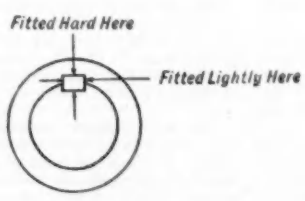
22—*Spline Shaft.*—A shaft having one or more splines. Spline shafts are designated by the number of splines, *e.g.*, six-spline shaft.



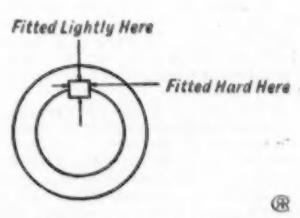
23—*Spline Hub.*—A hub having one or more splines.



24—*Serrations.*—A number of V-shaped splines cut in both members of a pair.



25—*Top and Bottom Fitting.*—When the key bears hard on top and bottom and lightly on sides.



26—*Side Fitting.*—When the key bears hard on sides and lightly or not at all on top and bottom.

South African Engineering Notes.

South African Inventions.

THREE mechanical inventions by South Africans are shortly to be exploited by South African companies. W. H. Manners and C. W. Spencer, of Krugersdorp, have invented a new type of carburetter for motor car and aeroplane engines. A big American manufacturing corporation is now testing the new device, and it is stated that trials carried out locally have proved eminently successful. The carburetter is operated on the rotary sleeve-valve principle, and attached to it is an arrangement by which the air supply is regulated. The apparatus, it is claimed, reduces to a negligible minimum waste of petrol in starting the engine and in acceleration, and by regulating the air supply, gives a better mileage per gallon than has been possible before.

Another invention is that of a Johannesburg man, Mr. T. P. Jones, and is designed to solve the traffic parking problem. A company has been formed to operate the idea commercially. The proposal, which introduces what may be termed "aerial parking," embodies the erection of a big steel framework stretching at a height across a thoroughfare. Attached to this framework are cubicles each of which will house a motor car and each of which can be raised or lowered separately.

Each of the cubicles carries a rent of £1 per month, and when an owner desiring to park his car arrives an attendant, by pressing a button, sets in motion gear which lowers the cubicle to ground level, and the motorist drives his car straight into it. The cubicle with the motor car inside is then raised to the framework, where it remains until it is again required for use. The process of raising or lowering the car does not occupy more than ten seconds. It is estimated that the cost of erecting parking accommodation for 100 cars would be £3500.

Mr. Jones has also invented a gate to be placed on the main road, and which, while it prevents cattle from going through it, allows motor cars to pass freely. It works on the principle of counterbalancing weights. A motor car on approaching the gate knocks against a steel pin with its bumper, with the result that the counterbalancing weights are brought into play, and the gate falls to the ground. The motor car passes over, and when it has got clear, the gate returns to its upright position. It is reported that each gate only costs some £3 to erect.

Railway Budget.

From the Budget speech of the Minister of Railways, Mr. C. W. Malan, which was delivered towards the end of March, it appears that the estimated income for the coming financial year is £31,181,118, while the estimated expenditure is £31,075,947, leaving an estimated deficit of £105,171. The Minister announced reductions in rates and fares, involving a surrender of £218,000 per annum. Improved rates of pay for European labourers, members of the clerical staff at the Grade III. barrier, and coloured labourers, involve an increased expenditure of £162,000 per annum. For the first nine months of the year ended March 31st last, nearly 800,000 tons more traffic was carried than in the corresponding period of the previous year, involving additional engine mileage of 4,152,149. Each additional £1 of revenue was obtained by an expenditure of 13s. 11d. Over 82 million passengers were conveyed, an increase of one million over the previous year. General merchandise carried increased by 212,214 tons, export maize 554,331 tons, other grain and produce 30,954 tons, and minerals and low-grade traffic 374,150 tons. In all, 914,136 tons export maize were conveyed, as compared with 359,805 tons in the previous year. During 1928 the road motor service continued to expand, and there are now 197 services compared with 157 for the previous year. The road route mileage now in operation is 9148 miles, while services sanctioned and awaiting inauguration total a further 1660 miles. The traffic dealt with during 1928 totalled 1,204,353 passengers, 99,436 tons of goods traffic, and 502,870 gallons of cream, reflecting an increase of 326,921 passengers, 47,367 tons of goods, and 209,681 gallons of cream over the previous year. A large proportion of this traffic was brought to the railway for conveyance by rail, so that the road motor services are directly helping to increase rail traffic. Partly owing to the great increase in the number of omnibuses competing, and partly owing to the heavy cost of the electricity supplied for the running of the electrified suburban lines—a charge of 1·6d. per unit is made—there is now a loss of £300,000 per annum on the Cape Town–Simonstown and Cape Town–Sea Point suburban lines. The total European staff employed on the railways is now 57,809, as against 38,285 in 1923, so that during that period employment had been found for 19,524 additional Europeans who have displaced native labour. This is in pursuance of the Government's policy of employing "civilised labour." The extra cost of the policy is said to run to over a million per annum.

Cape Town Electricity Supply.

During the year 1928 the distribution system of the city of Cape Town, which in the first instance comprised several different systems of supplies, was standardised, so that at present all consumers are being given a three-phase alternating-current supply on a 220/380-volt four-wire system.

During the year 1928 the total route length of the overhead distribution system which was reconstructed in continuance of this work, amounted to approximately 57 miles and involved the planting of 2740 poles, the erection of 162 tons of copper conductors, and 25,716 insulators supported on 6324 cross arms.

In conjunction with the reconstruction of the overhead network, it has been necessary to provide additional substations for transforming the energy transmitted from Dock-road power station at 12,000 volts to the low voltage of 220/380, suitable for distribution to consumers and to provide the necessary control switchgear and cables for this purpose. In some areas in which sub-stations existed prior to the commencement of the reconstruction work, it was necessary to augment or replace the equipment, and modifications were also made to some of the existing equipment to enable it to meet satisfactorily the new conditions. In this connection it may be mentioned that during the year eighty-five 12,000-volt metal-clad switchgeer panels, one hundred and one 380/220 volt metal-clad switchgear panels, thirty transformers and forty induction voltage regulators were installed in sub-stations, while six transformers were replaced, and, in addition, four rotary converter sets were erected and put into commission at Toll Gate, Burg-street, and Camps Bay sub-stations for direct-current supplies to the Cape Town and Camps Bay Tramway Companies. To feed the sub-stations with electric energy, 27,947 yards of 12,000-volt cables were laid during the year, and to distribute the supply from the transformers to the overhead network, 17,452 yards of low-tension cables were laid. For the purpose of telephone communication between sub-stations and the remote control of apparatus in them, 26,071 yards of telephone and pilot cables were laid. In some of the straggling and sparsely populated areas, sub-distribution points are arranged in pillar-boxes, and seventeen of these were erected and put into commission during the year.

The number of sub-stations in operation at the end of the year, excluding transformer pillars and kiosks, totalled sixty-two, and eight more were in course of construction or awaiting equipment.

Dry Recovery of Dust and Fume from Metallurgical and other Processes.

IN a paper on the Dry Recovery of Dust and Fume from Metallurgical and other processes, which was delivered before the Junior Institution of Engineers on April 11th, Mr. B. V. Lambert gave the following reasons for the growing attention which is being given to dust recovery in various branches of the engineering industry:—(1) The dust may be of value; (2) it may be obnoxious if allowed to settle in the neighbourhood of the plant; (3) that it may be an undesirable constituent of a gaseous product; (4) it may constitute an explosion or fire hazard and, lastly, but in many respects the most important; (5) it may be injurious to workers.

The first reason, it was explained, was specially exemplified in non-ferrous pyrometallurgical processes, in which the effluent gases might contain fine particles of the original charge together with vapours and volatile compounds of the metals under treatment, *e.g.*, fumes from copper, tin, silver, arsenic, and mercury furnaces contain suspended matter, the value of which far outweighs the cost of recovery. In such processes as the grinding of flour, coal, cement, pigment material, the production of carbon or lampblack, &c., the resulting dust was the sole object of the processes and its efficient and economical collection was all-important.

The second reason for recovery had reference to obnoxious fumes which might seriously damage vegetation or property, and the flue gases from boiler plants and cement kilns which might be a serious nuisance. Under the third catagory came coal gas and blast-furnace gases, which contained tar vapours or dust, that were detrimental to the plant using them. The fourth reason had special reference to the liability of finely divided matter of many kinds to form explosive mixtures when mixed with air, while its capacity for becoming statically electrified to a dangerous extent might provide a means for creating a serious explosion. The fifth reason was too well known to need detailed explanation.

The methods of dust collection or elimination, the author pointed out, varied in accordance with the nature, size, and other qualities of the substance to be dealt with. Speaking generally, apparatus employing centrifugal action, such as cyclonic separators and centrifuges, and settling chambers and friction plates, were most useful when the particles of dust were relatively coarse. Settling chambers should, in general, only be used as part of a multi-stage recovery process, and in cases in which it was desired to cool down hot gases preparatory to further treatment. Whilst those methods could account for a large proportion by weight of the dust, &c., they dealt with, there were smaller particles of the coarser dusts which would escape collection, and they would be of little value when the particles formed clouds, *i.e.*, those the diameter of which ranged from 10^{-3} cm. to 10^{-5} cm., and practically useless in dealing with smokes the particles of which ranged from 10^{-5} cm. to 10^{-7} cm. in diameter. For such very fine particles some form of bag filter or recovery by electro-static precipitation was essential.

The filtration of gases was, the author continued, usually achieved by passing them through long narrow bags composed of cotton, wool and other like substances in such a way that the uncleaned gas passed into the bag, the dust being retained on the inside walls and the cleaned gas issuing through the pores of the fabric. Mechanical shaking, or the action of grids travelling up and down the bags, precipitated the contents to the bottom of the bags from whence the dust fell into hoppers or trays, and was periodically removed. It was important that the right fabric, having regard to the nature of the dust to be collected, should be used. The texture of the cotton fabric was, generally speaking, not so close as woollen fabric, and the back pressure set up was therefore less. It was also cheaper than wool, but could not be used for gases with a temperature greater than 90 deg. Cent., nor was it suitable when acid was likely to be present. Wool fabric could withstand temperatures up to 120 deg. Cent., and did not appear to be affected by weak acids. Other special heat-resisting fabrics could be used to deal with temperatures up to 180 deg. Cent., with flash-over periods up to 200 deg. Cent. A well-designed system of bag filters could easily show an efficiency in dust collection of 99 per cent.

The electro-static precipitator was based on the principle that if a suitable electro-static discharge took place within a vessel containing smoke, the smoke particles were almost instantly deposited upon the walls of the vessel. Plants on that principle utilised current at a high potential—50,000 to 60,000 volts—which pressure was maintained between two electrodes, the discharge electrode being in the form of a straight wire, either hanging vertically within a metal cylinder or pipe, or between flat plates on to which the dust was deposited, and from which it was removed by automatic or manually operated rapping gear. The gases to be cleaned were passed through the tube or between the flat plates suspended in a flue. The collection efficiency of that apparatus might approach that of a good bag filter and was well adapted to the handling of gases at high temperatures and acid-forming gases. It was, in fact, much used in the precipitation of sulphuric acid mist.

SIXTY YEARS AGO.

IN our issue of April 23rd, 1869, we read a lesson to those who believed that the works of their forefathers would not bear favourable comparison with those of their own day, and that it was no difficult task to surpass the achievement of James Watt, George Stephenson, and Isambard Brunel. Too many engineers, we wrote, were in the habit of running down and depreciating the works of the mighty heads and hands that had gone before them. There was no foundation in reality for the assumption that the modern engineer had beaten and always could beat his predecessors by an immense distance. Hundreds of examples, both from the civil and mechanical branches of the profession, could be quoted to show that the men who had passed away had not only originated great inventions, but had developed them so far towards perfection that it was no easy task to improve on them. We gave one specific instance illustrating our argument. Within the preceding twelve months, we stated, a pair of very handsome Corliss engines had been put to work at Woolwich Arsenal. They represented the most advanced practice of the day. Careful records showed that their average consumption of very good coal was a little over 3 lb. per indicated horse-power. That figure represented, we stated, a most excellent performance, for very few stationary engines in the manufacturing districts burned less than 3½ lb. to 4 lb. per I.H.P. hour. Twenty years previously, namely, in 1850, it was calculated that the average coal consumption in the cotton factories of Lancashire was between 6 lb. and 7 lb. per I.H.P. hour. It would appear, therefore, that very great improvements had been made in steam engines during those twenty years. The improvement, we asserted, existed more in imagination than in reality. With certain exceptions steam engines of our day were, as regarded fuel consumption, very much what they were in the time of James Watt, who, we added, was not quite such a fool as some modern engineers would have us believe. Recently we had indicated a small factory engine built by Boulton and Watt and set to work in 1811. We found that its consumption of indifferent slack was little more than 4½ lb. per I.H.P. hour. Making an allowance for the difference between coal and slack, we could therefore say that the most improved engines of our own time were really only 1 lb. of coal per I.H.P. hour better than those built half a century previously. Moreover, for repairs during the sixty years it had been at work, almost without intermission, the engine we had tested had cost little or nothing, and it was still in excellent condition. When a modern steam engine had lasted half a century and was still in good condition we would be happy, if still alive, to admit that work done in 1869 was at least as good on the whole as that done by our forefathers.

ROAD CONGRESS IN THE UNITED STATES, 1930.

THE Minister of Transport has made the following announcement:—

"The Congress of the United States has authorised and requested the President to extend to the Permanent International Association of Road Congresses an invitation to hold the sixth session of the Association in Washington during the second week of October, 1930. The President of the United States has accordingly been pleased to issue an invitation to H.M. Government in Great Britain and Northern Ireland, and the Governments in the British Colonial Possessions, together with H.M. Governments in the Commonwealth of Australia, New Zealand and the Union of South Africa, and the Government of India.

"The Congress is intended primarily to bring together a widely representative international gathering of specialists for the presentation and consideration of the results of research and experience bearing upon all phases of highway development and use, and the United States Government have expressed the hope that their invitation will be transmitted to the individuals or corporations who are members of the International Association of Road Congresses, and who might desire to be represented at the meeting. It is expected that many members of the engineering profession as well as local administrators interested in highway problems will welcome this opportunity of studying under the most favourable circumstances the methods adopted and the results attained by their colleagues in the United States. The attendance at Washington is accordingly likely to exceed that of any previous meeting organised by the International Association of Road Congresses, upon which H.M. Government is represented.

"Further information as to membership, &c., can be obtained on application to the Honorary Secretary, British Organising Committee, Permanent International Association of Road Congresses, 7, Whitehall-gardens, London, S.W. 1."

A SCHEME for the prevention of the discharge of sulphurous fumes from the chimneys of power-houses has been suggested by Mr. A. E. Munby, of the Department of Scientific and Industrial Research. He proposes to inject finely divided lime and steam into the boiler flues, with the result that calcium sulphite and sulphate would be formed. These substances are solids and would be removed in the usual dust extractor. They might then be recovered for sale.

Railway and Road Matters.

THE Camden Town Station of the London Electric Railways will be the twenty-ninth "Underground" station to have escalators, of which there will then be eighty-five in use on that system.

THE new signalling at Manchester is already affording great relief to the working of trains. Observation on Tuesday, April 23rd, showed many of the business trains running into Victoria Station with "clear" signals all the way from Salford.

THE railway companies announce that they have informed the Railway Rates Tribunal that it is not their intention to put forward any proposals for a general increase of charges at the present time. This is in accordance with the anticipation advanced in our issue of April 19th.

THE provision recently, to the designs of Mr. H. N. Gresley, of some new travelling Post Office vehicles for the London–Newcastle service of the London and North-Eastern Railway, reminds us that such postal vehicles were probably the first to have the vestibule communication now universal in corridor trains. The gangways in those earlier vehicles, as in the Post Office vans of to-day, were at the side and not central.

WORK is being begun on a new training school at Lambeth North Station for the drivers, guards, signalmen and other grades concerned in the operation of the Underground Railways. The school will contain the latest forms of electrical and mechanical equipment, together with models of signals and lifts, and diagrams. The work will be completed in about two months. The Underground Railways now have a staff of 10,000 men.

NINE entirely new trains of the most modern type have just been put into service on the Piccadilly Railway. The whole of the original rolling stock of this line is being replaced, and twenty-seven new trains of six cars each are being supplied for this purpose. The old cars which have been in service since the line opened in December, 1906, are being sold as scrap, and the last will have disappeared by the beginning of July. The new rolling stock is identical with the new cars already in service on the Hampstead line.

THE assistant inspecting officers of railways held, during the three months ended September 30th, 1928, forty-eight inquiries into the more serious accidents to railway servants, of which twenty-one were fatal cases. Of the twenty-one men killed ten were employed on the permanent way. It was recorded that eleven were due to want of care on the part of those killed, one to want of care by a fellow servant, five to misadventure, and four——an unusual proportion—to the non-provision of a look-out man.

THE Liverpool Engineering Society, following the excellent example of the Stephenson Society as to the Stroudley locomotive "Gladstone," has raised funds to recondition the "Lion," which was built ninety-one years ago for the Liverpool and Manchester Railway. The "Lion" passed into the hands of the Mersey Dock and Harbour Board in 1859, and was used to drive a pump at the Princes Dry Dock. In September last it was replaced by an electric drive, and is now at Crewe being made fit for preservation at Lime-street Station, Liverpool

THE proposals of the railway companies for power to own, maintain and operate air services were the subject of a note in our Seven Days' Journal on April 19th. These have now been unanimously approved by the Joint Committee which has been considering the Bills, with the one condition—inserted on the representations of the Association of Municipal Corporations—that in every case in which a railway company makes application to the Air Council for a licence to establish an aerodrome, the Council must hold a local inquiry, at which any local authority concerned in the matter can attend and make representations, and the Air Council must have regard to such representations, as well as those of the railway company in its consideration of the matter.

THE Ministry of Transport railway statistics for January have recently been issued as a Stationery Office publication, price 3s. 6d. They show that the number of passenger journeys, when compared with January, 1928, increased by 3·6 per cent., but the receipts fell by 3·1 per cent. owing to 2,356,625 fewer passengers travelling at full fares; the increase in the journeys was brought about by 5,706,340 more making use of reduced fares, which also mainly led to a rise of 5·0 per cent. in the passenger train mileage. There was a gratifying increase of 9·35 per cent. in the tonnage of freight traffic, and of 6·15 per cent. in the freight traffic receipts, which, moreover, were earned with an increase of only 3·11 per cent. in the freight train mileage. There was an increase of 3·94 per cent. in general merchandise tonnage, 8·88 per cent. in minerals, and 11·80 per cent. in coal, coke and patent fuel. The average train load increased from 127½ tons to 130 tons, and the net ton-miles per engine hour—the speed of movement—from 416½ to 423¾.

How men, by the breach of regulations framed for their own protection, cause the injury and often the death of themselves and their fellow-servants was again indicated by an inquiry conducted by Mr. Scott Main into an accident to two platelayers on the Great Western Railway. They were engaged on a "one-man job," but instead of one man doing the work and the other acting as look-out man, the operation was not protected, and so both men were run down; one was killed and the other has lost his leg. The annoying fact is that in the previous March a circular was issued which provided that "when men are working in pairs on, or foul of, the lines of rail where danger is likely to be apprehended, they must agree, each with the other, as to which shall take the responsibility of acting as look-out man." The ganger over the two men was also to blame. Under the general rules, he is the man responsible for deciding whether or not a look-out man is necessary, and Mr. Main considers that in failing to do so the ganger was remiss. He further remarks that he was impressed with the fact that this particular ganger, with, no doubt, others in a similar occupation, requires some education in the responsibilities of his position, and action in that direction is suggested.

Notes and Memoranda.

A SCHEME has been initiated in America by the Common Brick Manufacturers Association, under which a bronze brick is built into every building that complies with the requirements of the specifications of the American Society for Testing Materials. This brick is accompanied by a certificate.

AN automaton, to which the name of "Telleur" has been given and which is described as brother to the famous automaton "Mr. Televox," has recently been on view at an Electrical Exhibition at Pittsburgh, Pa. It is the invention of Mr. S. M. Kintner, research expert of the Westinghouse Electric Company. The new automaton responds to rays of light instead of, like "Mr. Televox," to sound waves. In a test it turned off the lights in a room and turned them on again.

THE United States *Technical News Bulletin* reports on some investigations into the thermal expansion of refractories. Data were determined on the fire-bricks "as received" from the manufacturer, and after reheating in the laboratory kilns at 1400 deg., 1500 deg., and 1600 deg. Cent., showed that both the rate of expansion and total expansion of the majority of bricks decreased as the temperature of firing increased. These data also indicated that the thermal expansion behaviour of the finished bricks might not necessarily be the average rates of expansion of the clays entering into their manufacture. The modulus of elasticity of the bricks increased greatly at 550 deg. Cent. when compared with values obtained in tests made at 20 deg. Cent. At 1000 deg. Cent. the modulus of elasticity decreased greatly, *i.e.*, the bricks became less rigid and more subject to plastic deformation.

SOME trials have been made at the Pittsburgh Experiment Station with a powdered coal-fired boiler, in which the ashpit was closed and the ash was allowed to collect as a pool of molten slag. The percentage of the total ash fired which passed to the stack increased with the fluid temperature of the original ash. The percentage of the total ash fired which passed to the stack was about one-third less with a boiler having a slagging bottom than it was with a similar boiler with a dry bottom when burning the same coal. The slag from the molten bed would be expected to contain little combustible; as high as 8 per cent. combustible was found in some samples. The temperature of the gases entering the boiler tubes was 300 deg. to 400 deg. Fah. higher at similar loads and excess air in the furnace with the slagging bottom than in a similar furnace with a dry bottom and water-tube slag screen; this was due to the smaller area of heat-absorbing surface, larger area of high temperature surface, and smaller volume of the slagging bottom furnace.

REPORT No. 12 on engineering research of the Department of Scientific and Industrial Research deals with lanoline as a rust preventive. In it it is stated that by means of a process of wool washing now being introduced, large quantities of lanoline of a little greater acidity can be produced. Lanoline 4 and lanoline 5 in the report are samples of this material, which could be produced and sold at £15 per ton. A sample of much greater acidity known as "pale wool grease," and referred to as "Lanoline 3," has been tested. Large quantities of this can be obtained, but it is not entirely satisfactory unless neutralised. The quantities of lanoline which can be made available appear to be so great that there is no evidence that a rise in price would follow any probable demand for lanoline rust preventers. The material is therefore less costly than petroleum grease suitable for rust prevention, and its use would give an outlet for large quantities of home produced waste material in place of imported petroleum grease. The tests appear to show that such grease is superior to petroleum grease even when the latter is specially rectified without regard to the cost of such treatment. The report can be obtained from H.M. Stationery Office, price 1s.

IN the course of its investigation of the properties of sand lime, the United States Bureau of Standards has accumulated data on the strength of bricks. Twenty-five manufacturers supplied fifty bricks each, representing their regular production, for use in these tests. After drying to constant weight the absorption by total immersion in cold water was obtained at the five-minute, five-hour and twenty-four-hour periods. The absorption on boiling for five hours was also determined. Ten of each group of fifty bricks were then selected, taking care to obtain a range of absorption, and these ten were reserved for freezing tests, to determine the weathering properties of the brick. The other forty were dried and broken transversely to determine the modulus of rupture. The compressive strength of each half of each brick was then determined, one half having been tested on edge, the other half being tested flat. The results obtained thus far show that the absorption ranged from 13·7 to 21·6 per cent. of the weight of the dry brick; the modulus of rupture from 330 lb. to 730 lb. per square inch; the compressive strength, flat, from 2150 lb. to 4470 lb. per square inch; and the compressive strength, on edge, from 1500 lb. to 3850 lb. per square inch.

SOME experiments have been made at the Pittsburgh Experiment Station, on the deoxidation of steel with aluminium-silicon alloys, in order to find out the best method of deoxidising with aluminium and silicon. When there is only a small amount of aluminium in the alloy the inclusions formed are similar to those formed on deoxidation with silicon alone. As the aluminium in the alloy increases, the type of inclusion changes from a large glassy particle to a small particle which has some glassy characteristics, but is, mainly, of the amorphous type. These particles show high segregation at the top of small ingots and appear to coagulate in the steel much in the same manner as alumina. However, they segregate in the ingot proper quite differently from alumina because the particles are somewhat larger than the alumina particles. Even when the silicon content of the alloy is dropped to 8 per cent. the inclusions still show a considerable tendency to coalesce. If the deoxidation product can be made to coalesce somewhat, its chances of being removed from the steel are much better than deoxidation products which remain as a colloidal suspension, as is the case in deoxidation with aluminium alone. The ingots killed with these alloys showed an extremely low iron oxide content.

Miscellanea.

THE Fulham Council proposes to improve Wandsworth Bridge.

A WIRELESS factory is to be erected at Toronto at a cost of 203,000 dollars.

BOTH Port Elizabeth and Stellenbosch, South Africa, propose to install meters in all water supply services.

A COPPER smelting and refining plant is to be put up on the Pacific Coast of Canada by Consolidated Smelters.

IT is estimated that about 100,000 horse-power can be developed by two plants on the Campbell River, British Columbia.

THE manganese mines near Gafsa, Tunis, have now been developed to a productive stage. It is said that there are 400,000 tons of ore in sight.

AN airship hangar, which, it is claimed, will be the largest in the world, is being built at Akron, Ohio. It will be 1175ft. long, 325ft. wide, and 200ft. high.

THE existing 75,000 candle-power paraffin vapour light in the Green Point lighthouse, South Africa, is to be replaced by a 850,000 candle-power electric light.

THE Cape Peninsular Railway, which was recently electrified, is to be dismantled, as it does not pay, and it is proposed to make a vehicular road along the route.

AFTER lying idle for fifty years the cobalt mines in the Middelburg district of South Africa are again to be worked. The ore is said to contain about 15 per cent. of metallic cobalt.

IT is reported that coal seams extending over a depth of 69 m. have been proved on the Tete coalfield, Zambesia. Two of the seams are 14 m. and 15 m. thick, respectively, and are separated by only 1 m. of dirt.

DURING the past winter as much as 26,000 tons of power-house equipment and supplies were transported over snow roads to Island Falls, on the Churchill River, Northern Manitoba. The journey was 80 miles long and eleven tractors were employed on the job. The power-house is to have a capacity of 40,000 horse-power.

A REPORT issued by H.M. Eastern African Dependencies' Trade and Information Office in London states that a British firm is at present engaged in Kenya Colony on experiments for the manufacture of producer gas. It is also learnt that a patent has been taken out by a Kenya settler whereby a charcoal producer provides the motive power for tractors. The vehicles are said to have been successfully operated during trials in the highlands.

IT might be thought that for a pipe only 4in. bore a flat stop end ½in. thick, welded in place, would be ample to withstand any reasonable pressure, but that does not appear to be the case, for a recent official report concerns the explosion of such a pipe. It was installed as an expansion chamber in connection with a steam-heated oven, and failed at a pressure of about 1200 lb. per square inch, although it had been tested hydraulically to a pressure of 2240 lb. per square inch. The tube has been replaced by one with a hemispherical end.

AT a conference recently organised by the Association of Liquid Chemical Fire Extinguisher Manufacturers at the Institution of Mechanical Engineers, it was stated that the fire loss for last year was £10,628,474, an increase of £2,800,000 on the figure for 1927; and it was added that the most effective way to combat the growing menace of fire is to be adequately prepared to attack an outbreak at the start. Hand chemical fire extinguishers should be available in carefully selected positions for instant use. Many fires have thus been stopped at the start.

IN the Argentine Budget for 1929 provision is made for an expenditure on public works of over 157,000,000 pesos, of which it is estimated 100,000,000 pesos will be spent this year. Among the chief items are 11,523,000 pesos for conservation and upkeep of miscellaneous existing works; 9,824,500 for new construction; 13,021,900 for docks and harbours; 8,274,000 and 19,612,000 for new roads, bridges and aqueducts; 9,062,000 for irrigation; 31,500,000 for improvement of the State railways and additional equipment; 3,837,900 for navigation works.

CONSTRUCTIONAL work has been begun on the San Gabriel Dam, which is to form part of what is known as the Los Angeles Flood Control Project. The complete programme involves the building of seven dams, the aggregate cost of which will, it is said, be between £6,000,000 and £7,000,000. The San Gabriel Dam will be the largest of the seven; indeed, it is stated that it will be many times larger than the other six combined. It will necessitate the removal of more than 1,200,000 cubic yards of material for the foundations. The structure will be of the arched gravity type, with a radius of 1400ft. to the upstream radius. The length on the crest will be 2300ft. and at the base 660ft., the width at the base being 412ft. The crest will be no less than 432ft. above the stream to impound the water of which the dam is being built, and the width at crest level is to be 20ft. The surface area of the impounded water will be 1482 acres, and the capacity of the reservoir 240,000 acre-feet.

THE old standard of judging blast-furnace efficiency solely by the coke consumed per ton of pig requires revision, said Mr. Harold E. Wright (Dorman, Long and Co., Ltd.) in a paper read before the Cleveland Institution on April 8th. What was and is called the blast-furnace heat balance does not tell a true story unless to-day we take note of and consider the proper use of all the heat still available in the blast-furnace products. In the days when single-flued boilers and non-condensing blowing engines were in use, the whole of the gas and often some coal was used to run the blast heating and blowing plant. In those days coke consumption and heat balances came close to the fact. To-day, by means of up-to-date stove practice and gas blowing engines, all the heat and power required to run the furnace plant can be obtained from approximately 35 per cent., or at most 40 per cent., of the furnace gases, so that 60 to 65 per cent. exist for other uses. If boilers and condensing turbines are used for blowing, the surplus is rather less, but 50 to 55 per cent. should still exist.

THE SHANNON HYDRO-ELECTRIC POWER STATION

(*For description see page 452*)

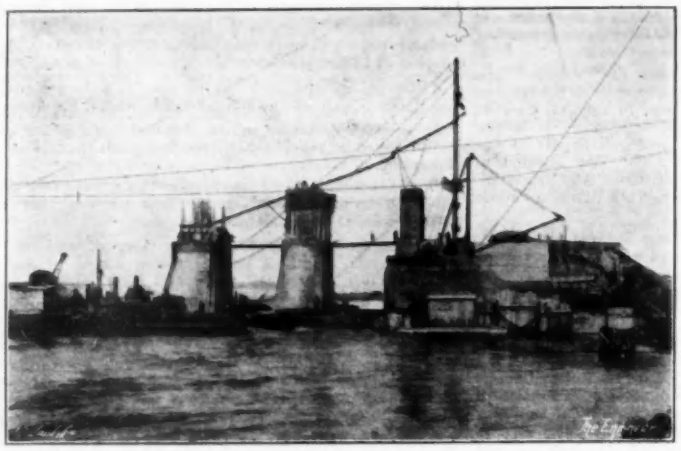


FIG. 9—CONCRETE PIERS AT WEIR

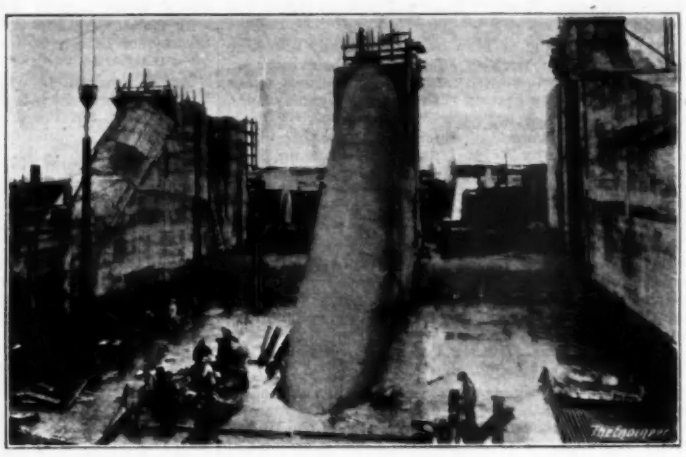


FIG. 10—CONCRETE GROUND SLUICES AT WEIR

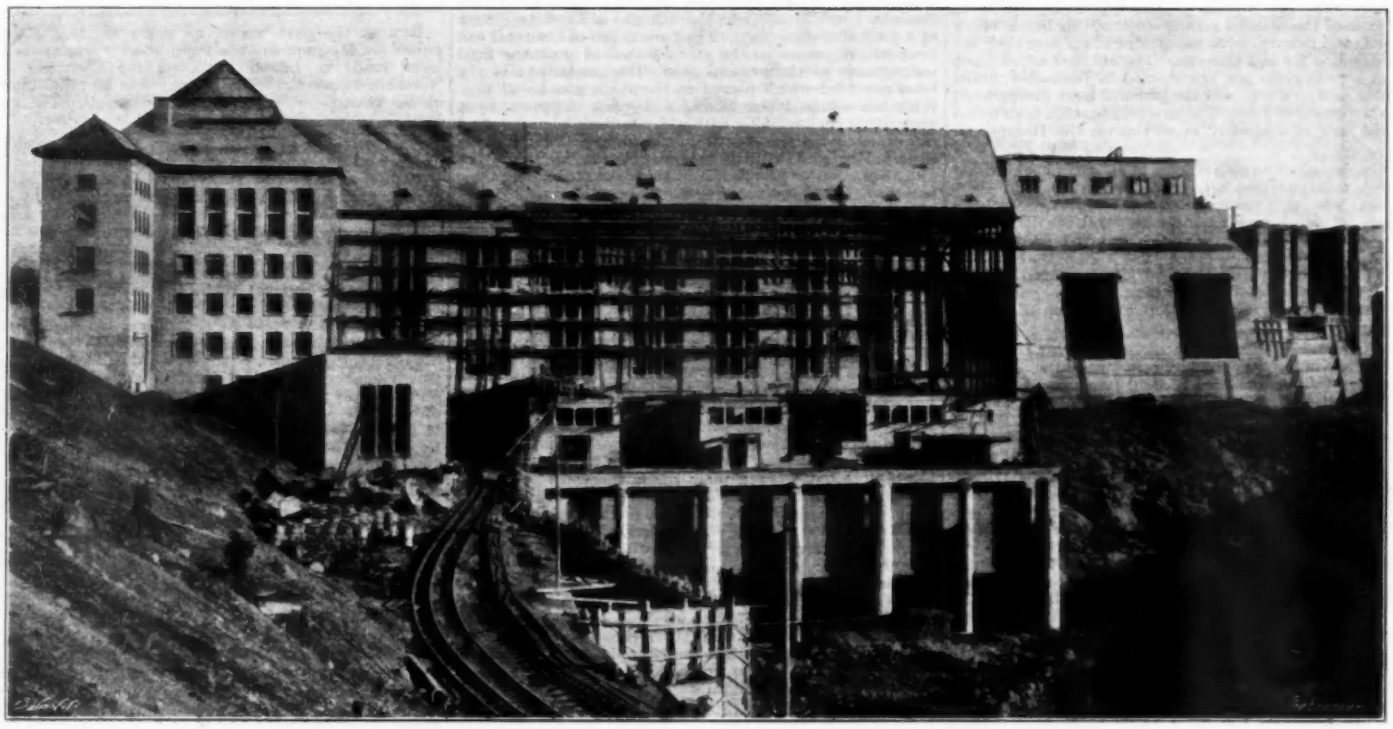


FIG. 11—POWER STATION, INTAKE BUILDING AND NAVIGATION LOCK

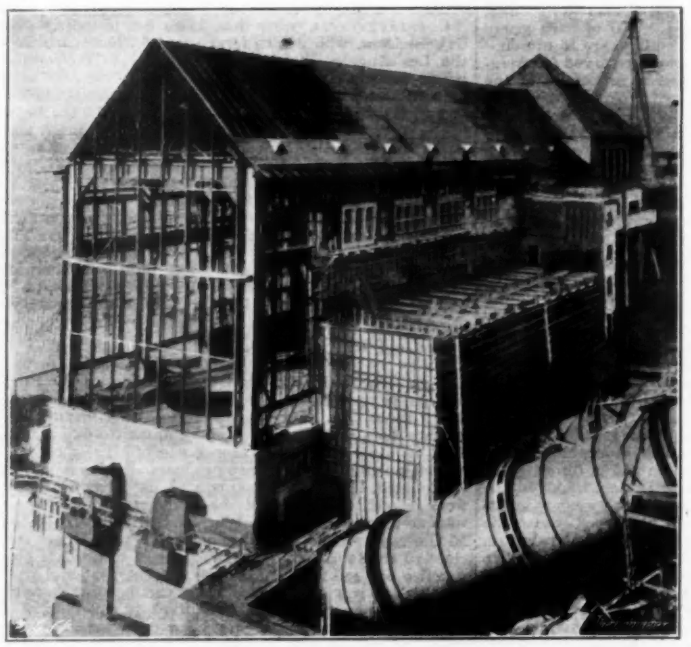


FIG. 12—POWER STATION AND 10-kV SWITCH-HOUSE

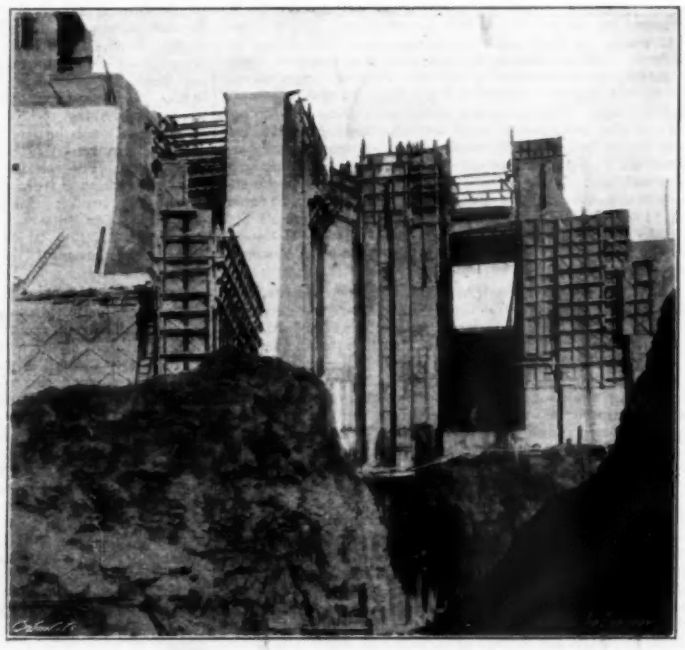


FIG. 13—NAVIGATION LOCK

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The Metallurgist.

THE APRIL NUMBER OF THE MONTHLY METALLURGICAL SUPPLEMENT TO "THE ENGINEER" ACCOMPANIES THIS ISSUE.

THE ENGINEER.

APRIL 26, 1929.

Railway Reform.

SOME three or four weeks ago a daily contemporary inquired why an interim report on privately owned railway wagons which was presented some months since by the Departmental Committee on Mineral Transport, had not been published. That Committee was one of the outcomes of the Samuel report after the coal stoppage of 1926. As recorded on page 631 of THE ENGINEER of December 7th last, Colonel Ashley stated, in reply to a question, that it was not then in a position to put forward any definite recommendations, as it had been found necessary to make detailed investigations into the existing facilities, the present user of wagons and other matters affecting the reference. The Minister of Transport added that the Committee was not likely to report until the early part of 1929. A week or so later, *i.e.*, about a fortnight ago, the same newspaper printed a leading article in which the alleged hindrances to economic railway working created by the privately owned wagon were advanced and the supposed benefits that would accrue from its elimination indicated. This article was clearly from the pen of a writer who knew his subject, and it was obvious that it was inspired by interested parties. It is safe to say that the private owner would not start such an agitation, as he prefers the present position, which assures him a good supply of wagons. Moreover, he is "in possession;" the privately owned wagon is older than the railway itself, and its presence on the rails is entirely due to the companies' own legislation, which exempts them from the provision of wagons for mineral and similar traffic. Certain arrangements affecting the railways were subsequently mentioned by Mr. Churchill in his Budget; but as he did not include any reference to privately owned wagons it may be assumed that proposals put forward by the companies were not entertained. The Budget proposals are that, as requested by a deputation from the Railway Companies' Association which waited upon Mr. Churchill early in the year, the railway passenger duty should be abolished and that the sum saved—something under £400,000 a year—be capitalised and spent in the development and modernisation of railway transport. The works contemplated, said the Chancellor of the Exchequer, "included such items as port equipment, terminal facilities, marshalling yards, and the adaptation of the railway system for dealing with heavier rolling stock." There is thus abolished a tax that, in the time of George III., was applied to stage coaches and was extended to railways during the reign of William IV. Its abolition could long ago have been justified, but it meant a loss of half a million a year to the national revenue, and the general public would have gained nothing by the concession, as the money came out of the railway companies' pockets; it was not a tax that was passed on. Mr. Churchill has, however, obtained something in return which, we trust, will not have the same ill-effect on the giver that the reciprocity of 1883, in the same relation, had. In that year the duty was taken off all fares except those that exceeded one penny per mile, on condition that the companies granted cheap fares for workmen, which has now become a costly return for so small a concession.

There is nothing in the conditions made by Mr Churchill—as indicated in his Budget speech, or by Mr Baldwin in his amplified remarks in the speech opening his party's General Election programme on April 18th—which concerns directly either the privately owned wagon or the companion question of the larger wagon; but as both subjects have received a good deal of public attention of late it seems desirable to remove certain fallacies. Whether privately or railway owned, coal wagons must be worked back empty. But if railway owned, instead of being taken direct to the colliery, they would have to be conveyed to large centres and thence, by another train, taken, often over the same ground, a second time, to the colliery. Furthermore, as the railways could not get rid of the wagons, as now, by shunting them into the colliery sidings, many miles of additional storage accommodation would have to be provided, and the greater the storage yard the greater the shunting mileage. Small wonder, then, that Sir Ralph Wedgwood told the Samuel Commission that were all railway wagons owned by the companies there would be a saving of only one penny per ton on the whole of the rail-borne coal and coke traffic. The larger capacity wagon, whether for coal or for general merchandise, is a not much better proposition. In October, 1923, the Great Western Railway adopted the suggestion made by Mr. H. N. Gresley in a paper entitled "Wagon Stock on British Railways," which was read at the Institute of Transport on February 5th of that year, and offered a rebate on the rail charges when coal was conveyed in 20-ton wagons. On that point, too, Sir Ralph Wedgwood had something of interest to say. He mentioned that for long the North-Eastern Railway had such wagons, and whilst the economies realised were real, they were not great. The large-capacity merchandise wagon has fewer claims than the big coal wagon. Critics point to those found on American railways, but the conditions between the two countries are not comparable. For instance, most of the small consignments in the United States are collected, packed, consigned and delivered by what we would call carriers, but which are known there as express companies. These firms concentrate their loadings to an extent not possible here under existing conditions. For some years, too, tradesmen in this country have ceased to keep a big stock of goods, for, thanks to the consideration shown by British railways, they can rely on a letter, telegram or telephone message bringing them the material they require within twenty-four hours. Economical working demands through-wagons from one town to another so as to avoid the delay of transshipment. Bigger wagons will need more trade to fill them, but they will not bring that trade. Hence the larger wagons must either be kept back until there is a full through-load or the consignments must be transhipped at a junction point and so suffer delay and be subject to damage. But if the companies detain the wagons until there is a full load traders will complain and send their goods by road. Motor competition is, in fact, a great obstacle to the adoption of the big goods wagon, and there is an ever-growing need for railways to give prompt dispatch and quick delivery. In fact, the small consignment governs the situation. According to the Railway Returns, the average loading per wagon is just over three tons, whilst

the average length of haul, in distinct contrast with the 260 miles in the United States, is only between 62 and 68 miles. As a consequence of the less loading of the British wagon the average load of our trains is only between 128 and 137 tons. The physical conditions here, moreover, somewhat handicap longer trains than those now run. Our stations, junctions, sidings, and level crossings come so close together that trains of greater length would retard their own movement. Finally, until all wagons are equipped with the vacuum continuous brake longer trains would involve more risks when ascending and descending steep gradients than are now experienced. Hence we feel safe in assuming that neither the elimination of the privately owned wagon nor the adoption of the big freight car will be a sequel to the abolition of the railway passenger duty.

There are, however, other directions in which railway reform is possible. Mr. Churchill mentioned marshalling yards. Therein we see a likely extension of hump shunting, with wagon retarders and automatically operated points, like those at Whitemoor Yard—see The Engineer of March 15th—wherein a train of sixty wagons can be broken up and be distributed in eight minutes instead of the customary half-an-hour. The Chancellor of the Exchequer referred also to terminal facilities. It is in the latter that the greatest weakness in British railway operation lies. No end of money has been spent on additional running lines, loops, signals, &c., to get trains more quickly over the road, but the capacity of the terminals to contend with the quicker arrivals has not been improved to suit. In that connection we offer the suggestion that, instead of enlarging the terminal accommodation in large towns, the use of reception yards outside, as at Willesden, Brent, Old Oak Common, &c., as concerns London, be extended and that the arriving wagons, after being sorted out, be taken to the main termini by shunting engines as the accommodation is available. Loaded wagons would be similarly taken in the opposite direction in batches and made up in the marshalling yard, into train loads. Such provision for arriving trains can be more readily extended and varied from time to time than can those at the terminus, to meet the quicker movement of trains out on the line. Much, too, can be done in the latter direction by more frequent crossings between fast and slow lines; the conversion of freight lines into passenger-carrying roads so as to allow fast trains to pass slow trains more quickly; the conversion of lie-bye sidings into running loops to facilitate rapid shunting; and the greater use of the vacuum brake on goods trains, which will allow them to run safely at a higher speed and to maintain steam longer when a stop has to be made, and is practically essential if the automatic train control, the coming of which, after recent accidents, would seem to be inevitable, is to be widely adopted. Hence it will be seen that there is ample scope for the profitable use of the £400,000 without touching upon two matters of uncertain economical value.

The Productivity of Labour.

Wages, time, and output are three factors common to all industries. They are obviously interconnected, and it is upon the maintenance of a satisfactory relationship between them that the prosperity of any manufacturing business depends. The workman is inclined to stress the importance of the wage-time ratio by insisting on the highest possible rate of pay per hour. The employer, concerned with production costs, knows that a high hourly wage is only compatible with a correspondingly high productivity, and hence has the wages output ratio constantly before his mind. It is upon these two ratios that most industrial arguments arise. The third ratio, that between time and output, must of necessity be satisfactory if the other two are, and for this reason perhaps its importance is apt to be neglected. Another reason may be that, since the question of money does not directly enter into it, it does not obviously affect the pocket of either party. It deserves, however, more attention than it gets. A man-hour when averaged over a large number of workers in a given trade, is a very definite unit of potential work, and the number of units of actual work which are derived from it, affords a useful measure of the efficiency of the organisation and equipment. This idea was very fully exploited in a paper entitled "A Basis for Evaluating Manufacturing Operation," presented by Messrs. L. P. Alford and J. E. Hannum, at the A.S.M.E. annual meeting in New York, last December. The authors proposed one thousand man-hours, or a kilo-man-hour, as they called it, as a convenient unit for the general measurement of labour expenditure, and illustrated their theme by comparing the quantities and values of goods produced per kilo-man-hour in various industries. It was shown, for example, that twelve companies, employing altogether 151,447 workers, turned out on the average 9·08 motor cars per kilo-man-hour; eight companies with 2276 workers produced 2·70 tons of machine tools for an equal expenditure of labour, and so on for some sixty-six different kinds of products. The value of the figures given is very little because there is no means of knowing who were reckoned as workers in each case, nor what proportion of ready-made parts entered into the products. If some firms or industries included draughtsmen, progress men, rate-fixers, foremen, timekeepers, general labourers, &c., as part of the production staff, whereas others regarded the skilled mechanics and machine hands alone as productive, enormous apparent differences in production efficiency would result. Similarly, no effective comparison could be made between, say, machine tool firms which obtained castings and fittings from outside and those which made them for themselves on the premises. Statistics, unless very explicit, and fully understood by those who use them, may lead anywhere. This, however, in no way detracts from the importance of the principle of correlating production with labour-hours. Once the output per kilo-man-hour, or per any other unit, is determined for a factory, whatever the basis of reckoning the amount of labour involved, it affords a check upon all future operation so long as the same basis is adhered to. Similarly, it permits of comparison between the efficiency of different factories manufacturing the same class of goods, provided, of course, that the equipment is comparable. It may, indeed, furnish a convincing argument for improving equipment, provided it is interpreted in the light of capital charges as well as of labour costs.

Since an editorial note in the *Journal* of the A.S.M.E. refers to the kilo-man-hour as a new unit, and seems to suggest that the idea of measuring production efficiency on some such basis is equally novel, we may be permitted to recount a little unpublished history. The acute shortage of labour felt during the latter part of the war will be well remembered. It gave rise to the formation of the Ministry of National Service, which, under Sir Auckland Geddes, was entrusted with the task of distributing the whole available man-power of the country in accordance with the direct and indirect needs of the war. Firms requiring labour of any kind to carry out their contracts made application to the Ministry, whose duty it was to see that men were transferred only to works where they were most urgently needed and where they would be most effectively used. The powers of the Ministry were equal to its responsibilities, even the Admiralty having to abide by its decisions. The latter were based upon definite, even if necessarily somewhat elastic rules. The "class of priority" of the contract in question naturally received first consideration. Then came the firm's record of efficiency. Statistics collected by the Ministry showed the total number of employees of the firm, including staff, divided into trades and ranged in classes of skilled, semi-skilled, unskilled women and boys. The weekly output was also given. When firms were engaged on different kinds of products the statistics referred to the various products separately. Two figures could be obtained from the records almost by inspection, namely, the production per labour-week and the proportion of unskilled to skilled labour. These were combined into a "figure of merit" for each firm or department, and in accordance with this figure of merit, applications for additional labour were judged. A firm with the highest figure of merit was not only employing the whole of its labour with the best productive results, but was also spreading the effects of the skill of its craftsmen over the greatest number of unskilled workers. Apart from exceptional circumstances, it was obviously the place where additional workers could be most fruitfully employed in that particular industry. We have mentioned these facts, not with any view of claiming priority for an idea so simple as to be self-obvious, but rather to support the claim that it may have useful applications. In the case quoted, matters were complicated by the war-time necessity of judging firms by their success in "dilution" as well as by their productive efficiency. The decision to employ the labour-week as a unit rather than a given number of man-hours, and to include every single person on the pay roll in the "labour," was taken after full consideration. It is simpler, and we think better, than the use of kilo-man-hours, and the inclusion only of certain classes of workers. It gives a preference to works where time-keeping is good, and avoids all computation of broken time. It also avoids all discussion as to the relative value of different lengths of working week. After all, what a man does in a week, and week by week, is at least as true a measure of his efficiency as what he does in a certain number of hours actually spent in the factory. The week is a natural unit of time, wages are made up weekly and outputs, in the majority of cases, are stated weekly. Then, as to the question of the number of men in respect of whom the labour-week is reckoned, there is much to be said in favour of including every man, whether black-coated or overalled, employed in the firm or department. No man, from manager downwards, would be on the factory pay roll were it not assumed that his services were directly or indirectly essential to production. If one starts by eliminating draughtsmen, timekeepers, rate-fixers, and others, a high apparent productivity per man may be shown, but there is no knowing when to stop. The fairest way to all firms is to include everybody on the pay roll, letting the internal organisation be as it may be. This, as we have mentioned, was the Ministry method.

By the end of the war there had been collected in the Ministry files an enormous mass of information of the highest industrial value. It pertained not only to the manufacture of shells, cartridges, guns and other munitions of war, but ranged over practically the whole field of manufacturing. The productivities per labour-week which had been obtained in rolling mills, brickyards, quarries, coke-oven plants, foundries of various classes, and in other works too numerous and too diversified to be catalogued, were all recorded. Had the figures ever been made public they might have caused much heart-burning, but they would certainly have contributed to industrial efficiency. The knowledge of what output a labour-week was capable of under really good management, would have stimulated those who were content with something far, and often very far indeed, below what was demonstrably attainable. High outputs were little related to extra efforts on the part of the workmen, for the latter, be it said to their credit, gave of the best that was in them in every factory. Previous training or experience did not count for much, except where very special skill was demanded. Nor did considerable differences of equipment have anything like the effect that might be supposed. The dominating factor seemed to be capacity of the management to ensure that the whole works ran with the smoothness and adaptability of a living organism rather than with the characteristics of an over-driven machine. This, and quite equally important, the constant belief that something better was possible and the resolute will to attain it, were the distinguishing features of the successful firms. The records of their achievements, as told by the bald figures of "output per labour-week," may still lie buried in some of the cellars of Whitehall, along with so much else that might well be published in the interests of manufacturing efficiency. The revival of the idea of comparing the productiveness of various factories on the basis of labour-time, by Messrs. Alford and Hannum, is to be commended, for with due regard to statistics being drawn up on a similar basis, it affords a useful means of appraising the efficiency of any organisation regarded as a means of turning human effort into consumable goods.

Cable Wire Breakages in the Mount Hope Suspension Bridge.

In our issue of April 12th last we reprinted an article, entitled "Broken Wires Cause Rejection of Cables on Mount Hope Suspension Bridge," which had been taken from the issue for March 28th of our contemporary, *Engineering News-Record*. This article mentioned that broken wires had also been found in the cables of the Ambassadors Bridge over the Detroit River. The same journal in its issue for April 11th last published an article entitled "Technical Aspects of Cable Wire Breakages on the Mount Hope Suspension Bridge," and in what follows we give a *résumé* of certain points brought out in the latter article. Our readers will recall that the cables of both these bridges, which were made up of wires obtained from the same source, manufactured to the same specification and treated in the same manner, are to be replaced because of breakages which were found in both of them.

It appears that the Mount Hope Suspension Bridge,

which spans an arm of Narragansett Bay, with the towns of Bristol and Portsmouth near to its north and south ends respectively, has a main span of 1200ft. with a 135ft. channel clearance and 504ft. side spans. From cable bents placed at the ends of the side spans the cables slope down sharply to the anchorages. The length of the bridge from anchorage to anchorage is 2648ft., and the structural steel towers are 284ft. high above mean low water. There are two cables, each 11in. in diameter, arranged 34ft. apart. Each cable consists of seven strands of 350 wires each. The separate wires, which are heat treated and galvanized, have a theoretical diameter of 0·196in., so that each cable has a total cross section of approximately 74 square inches. Actually, according to our contemporary, the wires run somewhat under the theoretical cross section and several more than the 350 wires were included in most of the strands. The seven strands are arranged in three tiers, two strands in the top, three in the centre, and two in the bottom tiers.

The original specification provided for the use of cold-drawn wire, but it was subsequently changed to admit of the use of a new type of wire hardened by heating and quenching after being drawn. The specification, states our contemporary, stipulated that check analyses of the finished or semi-finished wire should not show in excess of 0·935 per cent. carbon, 0·05 per cent. phosphorus, and 0·05 per cent. sulphur. The diameter of the wire, before galvanising, was specified as 0·192in., with a tolerance of 0·003in., and, after galvanising, as not more than 0·005in. larger in diameter than the bright wire. The specified tests required that the wire should bend continuously around a mandrel 2in. in diameter without developing cracks in the galvanising visible to the naked eye, and that it should bend continuously around a mandrel of four diameters without sign of fracture. The ultimate strength was placed at 220,000 lb. per square inch, minimum, on the gross cross section, the elongation at 4 per cent. in 10in., the reduction in area at 30 per cent., and the yield point at 190,000 lb. per square inch, the yield point being defined as the point at which the elongation of the specimen in a 10in. gauge length is 0·75 per cent. The test for yield point was required to be made on samples taken from 10 per cent. of the coils manufactured.

In describing the process of manufacture, which is said to be continuous, our contemporary explains that the wire, after being drawn, "is passed through a lead bath and oil quenched, the galvanising process following as an integral step in the manufacture. It is understood that the cold wire is first subjected to a normalising process in which it is heated in lead to a temperature well above the critical range and then quenched in another lead bath at a temperature well below the critical range. The wire is then again heated in a lead bath to the proper temperature for hardening, quenched in an oil tank and, as a final heating operation, is tempered in another lead bath to remove the oil. Following this the wire is washed, cleaned and galvanised in the usual way and wound upon blocks 5ft. in diameter. It is understood that any length of wire required may be manufactured, since electric welds, after being subjected to the heat treatment, have shown a strength and ductility approximating that of the rest of the wire."

The construction of the bridge was begun early in the spring of 1928 and progress was rapid. The cables were spun in the following September and October, and the main and side stiffening trusses and the floor system were completed by January 15th of this year. Early in February forms and reinforcing steel in considerable quantities were in place for pouring the concrete floor and the cables were stressed to about 32,000 lb. per square inch. The ultimate working stress was to be 80,000 lb. per square inch.

During the handling and the spinning of the cables nothing untoward took place, but in January three broken wires were observed. Six further breakages were noticed on February 8th and eleven additional fractures were discovered on February 19th. All these breaks—as were those which occurred later—are described as being at the strand shoes, at or close to the point of tangency of the wire to the curve of the back of the shoe. They did not affect any one strand in particular, but were scattered among the twenty-eight shoes of both anchorages.

Apparently, these breakages did not, at the time, give rise to any serious apprehensions, for the work of placing the floor forms and reinforcing steel was allowed to continue for several days longer. However, February 22nd being a holiday, constructional operations were suspended for the day, and, the occasion being taken advantage of to make an inspection, sixty-five broken wires were discovered in one of the Bristol side anchorages. On the next day a more careful examination was made of the same strand, and it was found that about 75 per cent. of the wires in it were broken near the shoe. No additional breaks were found in any of the other anchorages. Work on the bridge was, however, immediately stopped and measures were taken carefully to observe the cables, bands of paint being applied to the cables in various places so that any "slippage" taking place might be observed.

On February 27th ten broken wires were discovered at the Portsmouth West anchorage. They were all in one strand. In the Portsmouth East anchorage one new break was found in addition to one previous break. After a careful inspection on February 28th, "made by pulling each wire with a hook inserted into the different strands, seventy-seven additional broken wires were found at Portsmouth West. Additional broken wires were discovered on March 1st, and further ones on March 2nd." On March 11th, 90 tons of reinforcing steel were removed from the main span, as much snow as possible having previously been removed. "On March 4th a check on the damaged strand in the Bristol East anchorage showed that a total of 140 wires were broken. On the same day the final count in the Portsmouth West anchorage showed that 130 wires were broken, thus affecting 260 wires out of 360 in the strand (east strand of middle tier)."

On March 9th numerous other breaks were discovered at the Portsmouth end. In Portsmouth East sixteen breaks were discovered in one strand, and fifteen breaks in another strand. In the Portsmouth West anchorage eight new breaks were found. On March 13th an examination was made of the outside surface of the cables for their complete length and one break was found in the west cable of the Bristol back stay about 10ft. from the face of the cable bent saddle. This is believed to have been an old break made during cable squeezing.

Commenting on the breakages, our contemporary remarks:—"In the foregoing account of the cable wire breakages several significant points are to be noted. In the first place, the majority of the breaks occurred in two strands, one in the east cable and one in the west cable. In the east cable the breaks were localised in the Bristol anchorage very near the tangent point on the strand shoe. In the west cable the breaks were localised in the Portsmouth anchorage, but also near the tangent point. In the Bristol anchorage about 75 per cent. of the total number of wires in the strand were broken, while in the Portsmouth anchorage it is stated that 130 wires out of a total of 180 in a half-strand were found broken.

"Another point to keep in mind is that on March 9th, two weeks after the first breaks were discovered, eight additional breaks were found in the Portsmouth West anchorage and thirty-one breaks in the Portsmouth East anchorage; in the latter only two breaks had been discovered previously. Since careful inspection had been made of all cables daily since the first breaks were discovered, these additional breaks were evidently new ones. In the two-week interval no additional loads had been placed on the bridge—in fact, some 90 tons of reinforcing steel had been removed, and in addition the snow load had either been removed or had melted."

It is noteworthy that tests of the wire made prior to its adoption for the bridge all showed uniformly high results. Furthermore, the ultimate strength of the heat-treated wire—about 220,000 lb. per square inch—is not appreciably above that of wire which has been used heretofore in the United States. The cold-drawn wire in the Manhattan Bridge has an ultimate strength of 210,000 lb. per square inch; the specifications for the Philadelphia-Camden Bridge provided for 215,000 lb. per square inch. On the Fort Lee Bridge now under construction, the ultimate strength is designated as 220,000 lb. minimum and 225,000 lb. average. The wire of these bridges is galvanised; that of the Williamsberg Bridge is bare or bright. On the Portsmouth (Ohio) Bridge galvanising was omitted and the wire supplied averaged over 230,000 lb. per square inch.

In a short leading article in the same issue entitled "A Significant Record," our contemporary sums up the matter as follows:—

"Significant facts are brought to light in the record of events incident to cable wire breakages at the Mount Hope suspension bridge set forth on another page. The engineering world may well feel indebted to the engineers for making the record available promptly and fully. It shows that the wire breakage was a progressive happening, something which evidences a mysterious time factor in the failure of the metal. First of all this progressive effect is evident in the sequence of events at the Bristol East anchorage, where wires continued to break during a two weeks' period of frequent and meticulous inspection after breaks were first discovered in considerable number. While there is some room for believing that the additional breaks here may have resulted from gradual redistribution of load among the wires as one after another went out of service, the argument is not very satisfying. That breakages began at the Portsmouth East anchorage fully two weeks later is subject to a similar counter-argument. But the case is placed beyond doubt by the Portsmouth West cable breakages. Substantially all of these occurred after the first trouble developed in the opposite cable and during a period when the load on the structure was decreasing; they cannot well have been induced by the weakening of the east cable, nor by any increase of demand placed on the cable, but represent spontaneous failure under steady, quiescent load, a load which the cable had borne for weeks without injury, but which finally produced a break. Such behaviour of steel is new in structural history; nothing resembling a time effect of loading has been previously observed, even at full working stress, let alone at the very low stress which the cables bore at the time they failed. It is to be remembered, of course, that no structures heretofore have used a hardened and tempered spring steel wire, cold bent as was this cable wire at the place where the breaks occurred. It remains to be seen whether the cables in removal will show any breaks elsewhere in their length, and it also remains to learn fully the physical conditions and the circumstances under which the breaks can be duplicated. Full research into the behaviour of the steel is a problem of most pressing urgency."

Institution of Mechanical Engineers.

A PAPER entitled "The Standardisation of Keys and Keyways," by Mr. William Reavell, Past-President, was presented and discussed before the Institution of Mechanical Engineers last Friday evening. This paper will be found reprinted elsewhere in this issue. It may be described as summarising the work and findings of the British Engineering Standards Association's Sub-Committee on Keys and Keyways, of which sub-committee Mr. Reavell was the chairman.

Mr. Daniel Adamson, the President, following the presentation of the paper, remarked that there was still plenty of work for the B.E.S.A. to do. It had been suggested that it might turn its attention to plummer blocks and standardise the base and height of centres, to the feet, height of centres and perhaps speed of electric motors, to the height and length of steam stop cocks, and so forth. Dealing with standardised keys and keyways, he asked Mr. Reavell how the depth of immersion of the key was to be measured in practice. The sub-committee's rule was that the depth of immersion was to be measured at the side of the keyway and was to be half the depth of the key. In the shops the depth of immersion would be measured by placing a rule down the side of the keyway, but he thought some more accurate process of measurement was required. He believed that it was less difficult to measure accurately the depth of immersion from the circumference of the shaft at the centre of the width of the key than to measure it at the side of the keyway. Speaking, as he afterwards explained, in a Pickwickian sense, he said that the work done by the sub-committee was excellent, but was unnecessary, in that loose keys were things of the past. Modern improved practice replaced them by an excentric collar turned from the solid on the shaft, with a corresponding excentric recess in the hub.

Mr. C. le Maistre, secretary to the B.E.S.A., spoke on the subject of standardisation in general. He hoped that the keys and keyways standards specifications, now that they had been adopted, would be widely used. Some of the Association's specifications were not employed to anything like the extent to which they should be. At first it was inevitable that articles made to a standard specification should be more costly than the non-standard articles which they were intended to replace. But with increasing use of the standard articles, the difference in cost would disappear and probably become in favour of the standardised article. He dwelt on the significance of the fact that the sub-committee had standardised both square and rectangular keys and left the choice as to which should be employed to the user. In some of the Association's earlier specifications the purpose for which the standard parts were to be used had, he thought, been indicated too closely. The Association to-day was trying to get away from that tendency. The whole question of standardisation in this country had as yet hardly been scratched. He suggested that the rating of machinery might be standardised and that such work would be much more valuable than the fixing of the dimensions of plummer blocks, &c. The future of standardisation as it affected the mechanical engineering industry of this country could not be in better hands than those of Mr. Reavell, who had been appointed chairman of the Mechanical Industry Committee under the new scheme of subdivision of the Association's work.

Mr. H. G. Burford said that the success of the automobile industry in the United States was founded on standardisation and simplification, and he thought that if we also adopted these two movements our automobile industry would advance to the forefront. The standardisation of nuts and bolts and of steels had resulted in enormous savings to the industry during the past ten years.

Engineer Vice-Admiral R. W. Skelton remarked that the standardisation of keys and keyways was of paramount importance, not only because it conferred on manufacturers the commercial advantages attendant upon all forms of standardisation, but because it prevented individuals from giving free rein to their imaginations when designing keys, which keys so produced might be a very real source of danger. Keys and keyways were potential sources of weakness, and in recognition of their shortcomings, it was usual in certain highly rated machinery for naval purposes to machine the keys solid with the shaft. He was particularly interested to note that the sub-committee recommended that keys and keyways should have their corners rounded. He was in entire agreement with that recommendation, for there was ample evidence that sharp corners constituted a weakness. It was amusing now to remember the great care that

used to be taken to make the corners as sharp as possible. Dealing with the question of keys and keyways on coned shafts, he said that the largest examples of such shafts in naval practice were for propellers. It was customary in the Navy to base the width of the key on the mean diameter of the cone and not on the greatest diameter, as recommended by the sub-committee. He recognised, however, that it was advantageous to base the width on the greatest diameter of the cone. The size of the key would then depend only on the original diameter of the shaft and not on the length of the cone. In addition, it was strictly logical from the point of view of torsional deflection to work on the basis of the greatest diameter. Woodruff keys were not much used in naval practice. While agreeing that the firmness with which such keys were embedded in the shafts was all to the advantage of the keys, he could not lose sight of the fact that there were corresponding disadvantages as regarded the shaft. There was a certain amount of evidence that in shafts rotating at a high speed a single key and the abrupt change in diametral moment of inertia which it produced might be highly undesirable from the dynamical aspect in so far as it might affect the critical speed. He was therefore glad to observe an increasing tendency in such cases to fit several keys instead of but one.

Mr. R. G. C. Batson, of the National Physical Laboratory, mentioned that certain of the figures—for example, those relating to the hardness of the steels experimented with—given in the paper were not strictly comparable among themselves, because some had been recorded from experiments conducted before the war when testing practice was different from what it was to-day. The experiments conducted for the sub-committee in the earlier stages of its work had shown that the prescribed depth of immersion of the key was slightly on the small side. That fact had been met by changing the depth of immersion from half the key depth as measured from the circumference of the shaft on the centre line of the key to half the key depth as measured down the side of the keyway.

Mr. R. C. Macdonald said that while the standardisation of keys and keyways had no doubt been done for the benefit of the manufacturer, it would also help the user by enabling him to reduce the number of spare parts which he had to carry. He uttered a warning, however, that the ease with which standard key bars could with a touch of the file be brought to size might lead to slipshod work. In millwright work it was particularly essential to have good fitting at the keys. He gave an instance illustrating his objections to the common practice of making taper keys in couplings fit tightly on the sides, but easily on the top and bottom of the taper.

Mr. E. R. Briggs held that the nature of the work should be taken into consideration in discussing the question of side *versus* top and bottom fitting in keys. If dynamic balance was of vital importance two keys 180 deg. apart should be used, and they should be fitted on the side. If, however, the parts to be connected were of the nature of a crank and a shaft, the key should be fitted on the top and bottom, so as to draw the hub tightly to the shaft, even at the expense possibly of a slight distortion.

Mr. Charles Wicksteed held that there should be no side fitting on keys, and that if the fitting were on the top and bottom, the driving of the key into position would cause it to swell sideways to all the extent required. It was essential that the boss should be a good fit on the shaft. If it were not tightness would never be attained, no matter how good the key fitting was. Square keys, he held, were an abomination.

Mr. L. A. Legros sympathised with the sub-committee in its endeavours to standardise nomenclature. There was not even general agreement as to the meaning of simplification, which might be described as the elimination of useless types, rationalisation or the elimination of unnecessary number of sizes and standardisation or the fixing of sizes, tolerances and allowances. Standardisation should not, he argued, be allowed to interfere with evolution, but should be accompanied by it. For example, Whitworth standard threads were satisfactory in the days of iron, but for steel they were out of date. He argued that it was most necessary that keys and keyways should have rounded ends and edges, and in general that they should be carefully designed. As an illustration of the possibilities latent in bad design, he described an accident to a vessel in Ostend Harbour. The hub of the reversing lever moved longitudinally on a shaft and was prevented from rotating thereon by means of a key which was held to the shaft by a grub screw near each end. The engineer received a sudden order to reverse his engines, but one of the grub screws had worked loose and was standing above the face of the key. As a consequence, the lever could not be pulled fully back, the engines could not be reversed, and the ship crashed into another at anchor.

Mr. Reavell very briefly replied to the discussion. Nothing, he remarked, had been said that would require the sub-committee to change any of its recommendations. He himself had only been chairman of the sub-committee. The work involved in the preparation of the specification was the sub-committee's and not his personally.

A Low-lift Screw Pump for Surface Drainage.

A SCREW pump installation at Dirtness Pump Station, Hatfield Chase, provides a recent example of vertical "open" type direct-driven screw pumps, built and installed to the instructions of Messrs. J. Simmons and Son, consulting engineers, of Doncaster, by Hathorn, Davey and Co., Ltd., of Leeds, in accordance with the "Gill" screw pump patents.

The pumps in this station are two in number, one of 52in. diameter for a rated discharge of 200 tons per minute, and one of 37in. diameter for a rated discharge of 100 tons per minute against a total hydraulic head of 6·5ft. The larger pump and its runner are illustrated by Fig. 1. They were put in to replace a large beam engine-driven scoop wheel and deal with the surface water from an area of

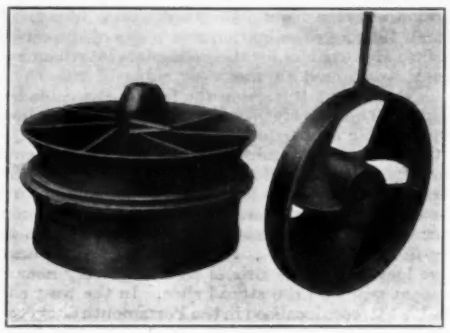


FIG. 1—SCREW PUMP AND RUNNER

some 10,000 acres, collected by a system of surface drains above the pump station and discharged through an outflow channel of about 40ft. width to the tidal water of the river Trent at Keadby.

In order to avoid material alterations to the existing wheel pit and to reduce new masonry work to a minimum, whilst effecting the best economy of space, it was decided to put in vertical spindle submerged pumps, in very short casings, driven direct by electric motors and discharging through balanced flap doors, the smaller of the two pumps taking its water from a lower level on the inflow side than does the larger pump. The short axial length of the pump casings, though precluding the adoption of gradually expanding passages for the conversion of flow velocity energy into static lift, has certain advantages in consideration of the site conditions.

Both pumps are of cast iron and have two-part casings with an external flanged joint, the flange of the lower part of the casing serving also to support the pump on H-section joists built into the concrete walling of the pump well

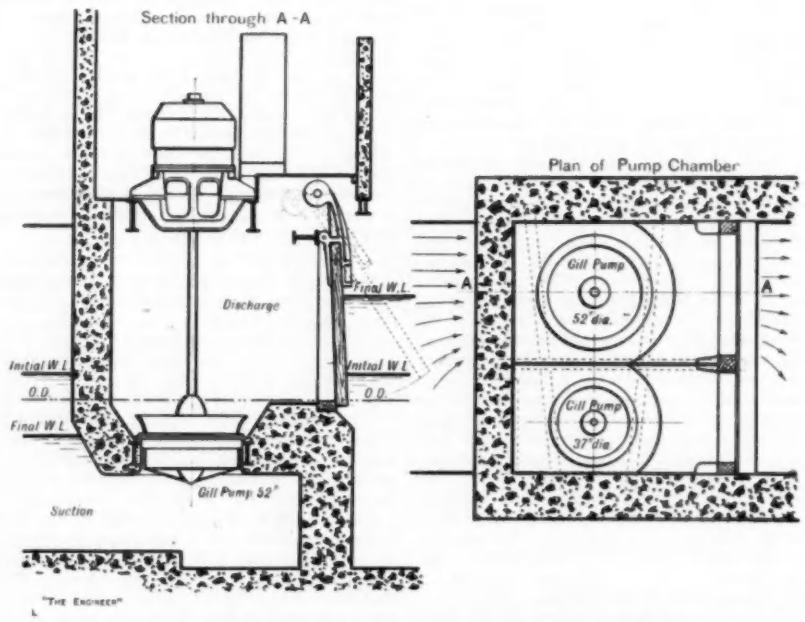


FIG. 2—ARRANGEMENT OF PUMPS IN PUMP CHAMBER

platform. The larger pump has a shrouded rotor of 52in. diameter, mounted between guide vanes which are cast into the lower and upper parts of the pump casing. In the bossing of the upper set of guide vanes there is a radial bearing with lignum vitæ bushing for centring the shaft of the pump rotor, and this shaft is extended upwards to a Michell thrust bearing and the spindle of the electric motor, the drive being transmitted by means of a pin type flexible coupling. The cast iron bridge piece carrying the thrust bearing and the base of the electric motor is supported on two H-section joists spanning the pump chamber, whilst another H-section joist supports the balanced wooden flap door which separates the discharge channel from the pump chamber—see Fig. 2.

The details of the 37in. pump and mounting are similar to those of the larger pump, with the exception that there is a downwardly projecting cast iron bell-mouth fitting on the suction side of the pump to provide for pumping from a lower level than that from which the larger pump is set to operate.

The larger pump is driven direct at a normal speed of 238 revolutions per minute by a Crompton-Parkinson motor which operates on three-phase, 50-cycle, 400-volt current from the Ferrybridge station of the Yorkshire Electric Power Company, Ltd., through Igranic control gear. The smaller pump is driven direct at a normal speed of 316 revolutions per minute by a second motor of the same make. The switchgear for both pumps is mounted adjacent to the motor platform and each pump is arranged to cut out automatically when the water on the suction side has fallen to a predetermined level.

TESTS.

Both pumps were put into service in the autumn of 1928, and showed good economical results in performing the normal pumping of the drainage area. In December last it was decided to obtain an accurate record of performance from the larger pump and, as the results will be of interest to engineers concerned in similar drainage operations, they are detailed in the diagrams accompanying this article. The tests were made under the supervision of Mr. John Simmons, M. Inst. C.E., of Doncaster, the consulting engineer for the local Drainage Authority.

Before this pumping test was undertaken a temporary timber dam was put in across the discharge channel about 2 miles below the pump station, and a distance of 100 yards was carefully measured off and marked by poles on both banks along a section of the channel about 150 yards on the downstream side of the pumps. Cross sections of the channel were taken at four points along this measured 100 yards, where there was little variation in the channel section, and a mean section was determined from these observations.

The sluice door at the pump station was opened before the tests and a uniform still water datum was established in both intake and discharge channels at 1·3ft. above Ordnance Datum. This initial still water level was recorded on two fixed graduated staves having different zero readings, set in the forebay of the pump intake and from two bench marks, one on the floor of the pump house clear of the line of discharge water and one on the parapet of a bridge spanning the channel on the upstream side of the measured 100 yards.

Floats had been prepared in the form of wooden cylinders, 12in. long and 6in. diameter, ballasted with lead until their upper ends floated flush with the surface of the water and fitted with light metal rods projecting above the surface. A wire netting screen was fixed across the channel to intercept these floats on the downstream side of the measured 100 yards.

The 52in. pump was started on test at 12.20 p.m. on December 16th, with the still water level at 1·3ft. above Ordnance Datum on both intake and discharge sides, as noted. The height and speed of the initial "bore" flowing down the channel was observed, and the elevation of the "dome" of water immediately above the pump was noted with reference to the water level in the discharge chamber.

At 1 p.m. the flow conditions in the discharge channel were "steady" and the float measurements were undertaken. The floats were started from the bridge about 50 yards on the upstream side of the measured 100 yards, and they were run in pairs at about one-third of the channel width from each bank, with a definite interval of time between the departure of the two floats of each pair. Observers were stationed in line with the poles marking the two ends of the 100 yards' run, whilst the times of the floats starting and of their passing each end of the measured distance were signalled to and noted by two other observers taking independent time records.

Water surface levels from the bridge bench mark were taken and recorded for each run, whilst those from the pump house bench mark were taken towards the two ends of the period of the test. The water levels on the two graduated staves in the forebay of intake were taken by another observer at intervals throughout the test.

The floats ran very consistently, both as to their respective distances from the channel banks and as to their intervals of departure and arrival.

The observations of float run times and of the water levels at the positions of intake and discharge side readings were subsequently plotted and fair curves were run through the observational spots recorded against a base of time. The float run times are spotted in Fig. 3 and the water levels in Fig. 4.

The float speed records being transformed to feet per

second from the curve of speeds over 100 yards were then reduced by a factor obtained from similar experimental channel flow tests published by various recognised authorities, varying in value from $x \cdot 80$ for the initial runs when the water was shallower to $x \cdot 85$ for the final runs when the water was deeper. It should be noted that this factor, which is normally deduced from central flow speed, is in this case applied to flow speed at one-third of the channel width, to ensure a conservative assessment of flow. The cross sectional area of the channel contents at each float run observation was computed graphically from the water level at that time, plotted on the average cross section of the measured length of channel. The curve of discharge volume was plotted on a base of time from the corrected flow speeds and the computed areas, as noted above. The net differences of level between the intake and the discharge side of the system as given by the intercepts between the curves drawn through the observational spots in Fig. 4 were re-plotted as ordinates to a curve of net lift—see Fig. 5.

Observations of electrical horse-power input and of revolutions per minute were made at regular intervals throughout the test by means of three wattmeters and a tachometer, the E.H.P. readings being transformed into B.H.P. by applying the efficiencies recorded in the maker's works test on the motor.

To obtain a record of the water horse-power output of the pump for computing its efficiency in the same way that this factor is obtained in pump makers' works and in official tests, where manometer gauges are fitted to orifices in the suction and the discharge pipes of the pump and the pressure or hydraulic head is represented by the algebraic sum of their minus and plus readings, it is necessary to ascertain the difference of pressure which was generated "across" the pump, as though it were situated in a horizontal pipe of parallel bore with these readings recorded by manometer. This can be done conservatively by computing the head due to the velocity of flow in a pipe of 52in. diameter, corresponding with the ascertained quantity of discharge at each observational time and adding this to the recorded net lift to obtain the manometric difference of pressure or hydraulic head generated across the pump, as this would be recorded in a pipe of the same diameter as the pump.

This procedure produces figures which are less than the true values for manometric head, because the net cross-sectional area for flow through this 52in. pump is under 13 square feet, whereas the net cross-sectional area of a 52in. pipe is approximately 14·7 square feet. The head component which is due to flow velocity as determined by this method will therefore be $1 - 13^2/14 \cdot 7^2$ = say, 22 per cent. less than the velocity head component actually across the pump itself.

This reduced assessment of the velocity head component, in its effect on the manometric head of which the velocity head constitutes an important proportion, will involve an under-assessment of the actual working efficiency of the pump, but will remove any doubt of the conservative nature of the efficiency deduced from the test results.

It is interesting to note that observations made in the pump chamber at intervals during the test run showed that the elevation of the "dome" of water over the pump, above the level of the water in the discharge chamber, corresponded as nearly as could be estimated with the head due to the velocity of flow through the pump itself. This "dome" showed a flattish top with a slight central depression and was ribbed or streaked in radial directions with no appearance of whirl in the water discharged.

The results of the test are shown in the accompanying diagrams, Figs. 5 and 6, which can be taken as representative of the performance of a modern and compact type of screw pump operating under somewhat stringent limitations as to space and method of mounting, with relatively high flow velocities through the pump. The flat shape of the efficiency curve, which in this case shows efficiencies ranging between 70 per cent. and 76 per cent. over a wide percentage variation in head and quantity, is a characteristic feature which is typical of the performance of pumps of the type described. It should also be noted that the values shown by this efficiency curve represent the net energy imparted to the water by the pump divided by the power input to the pump spindle, without any allowances for light load losses, for internal hydraulic friction, or for possible recovery of velocity head between the 13 square feet area of the pump and the 14·7 square feet area of a 52in. pipe.

IT will be remembered that in the Charfield accident of October 13th it was alleged that the distant signal was giving a false "clear" indication. To support that contention the men's societies were very active in finding instances elsewhere of that character in order to show that such a thing had happened before. It was the same after the Ashchurch collision of January 8th, and that has led Lieut.-Colonel Mount, in his report on the latter case, to say that the adequacy of balance weighting is of importance, having regard to the increasing distance at which signals have now to be worked. Colonel Mount adds that in view of the liabilities consequent thereon, he would call attention to the security afforded by interlinking the distant signal with the block apparatus, whereby the arm is proved to be in its normal position, otherwise "line clear" cannot be sent on the block instrument for a train.

The Rainhill Trials of 1829.*

By C. F. DENDY MARSHALL.

THE Act of Parliament authorising the Liverpool and Manchester Railway was passed in May, 1826, and work was begun in June. By 1829 it was fairly well advanced, and it became absolutely necessary for the directors to come to a decision as to the motive power to be employed.

In September, 1828, they had sent a deputation to Darlington to inspect the working of the railway there, and at the beginning of 1829 they commissioned James Walker and John Rastrick, both well-known engineers of the day, to visit certain colliery railways and report as to the comparative merits of locomotive and stationary engines. Their report, while leaning to the side of fixed engines, was far from decisive, and the question was summed up by Walker to the effect that if it was wished to make the railway complete at once, the stationary system was the best, but if preferred to proceed by degrees, and proportion the power of conveyance to the demand, they recommended locomotive engines on the line generally, with two fixed engines on the Whiston and Sutton planes, to draw up the locomotives, as well as the goods and carriages. (Another was required for the tunnel at Liverpool; the only one that was eventually installed.) He then went on to suggest that if the latter plan be adopted, something in the nature of a premium might be held out for the best locomotive.

Acting on Walker's suggestion, a prize of £500 was offered for a locomotive engine "which shall be a decided improvement on those now in use, as respects the consumption of smoke, increased speed, adequate power, and moderate weight." [1]

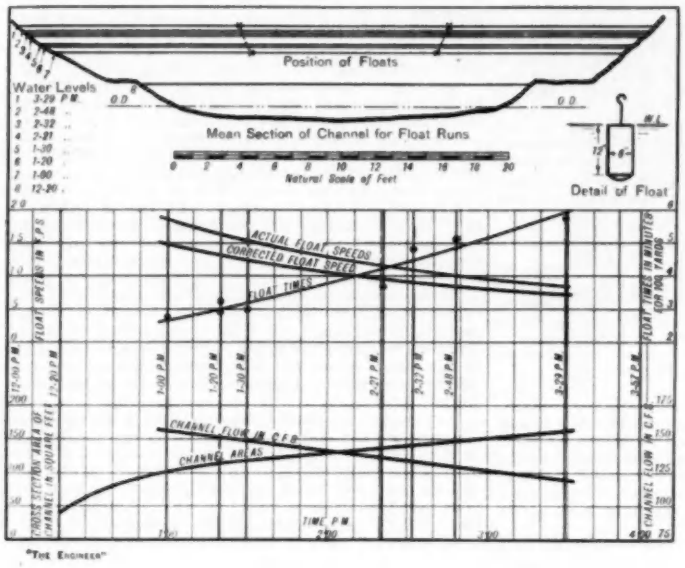
By this time nearly every place where there was a mine had some sort of railway, locomotion being effected in four ways—(1) horses, (2) self-acting planes (in these the loads were all downhill, and gravity supplied the power), (3) stationary engines hauling the vehicles by means of ropes, (4) locomotives.

Fifty railway locomotives had been built in England; two in Germany, which would not go; and one, a mere model, in the United States. Two of ours had been exported to France, and four to America.

About half the above were actually at work.

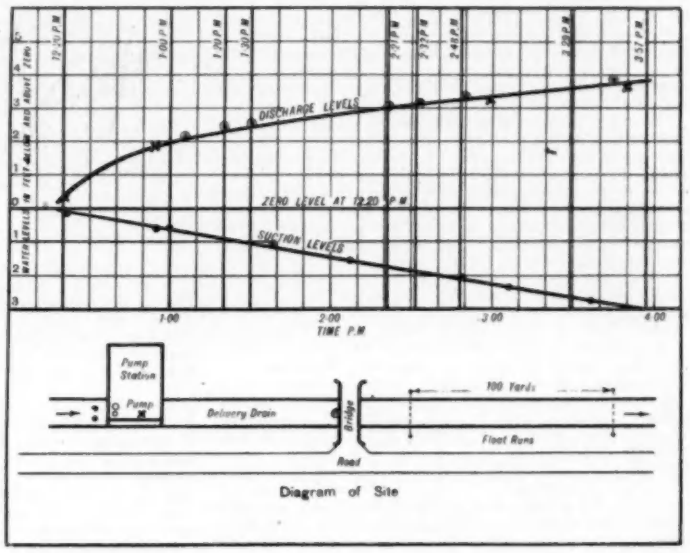
The conditions laid down by the directors were printed on a card. To summarise them: The engine had to consume its own smoke; have two safety valves, one locked up; be on springs; and not to exceed 6 tons in weight and £550 in price. If under 4½ tons, it might be

* Paper read before the Newcomen Society, April 24th.



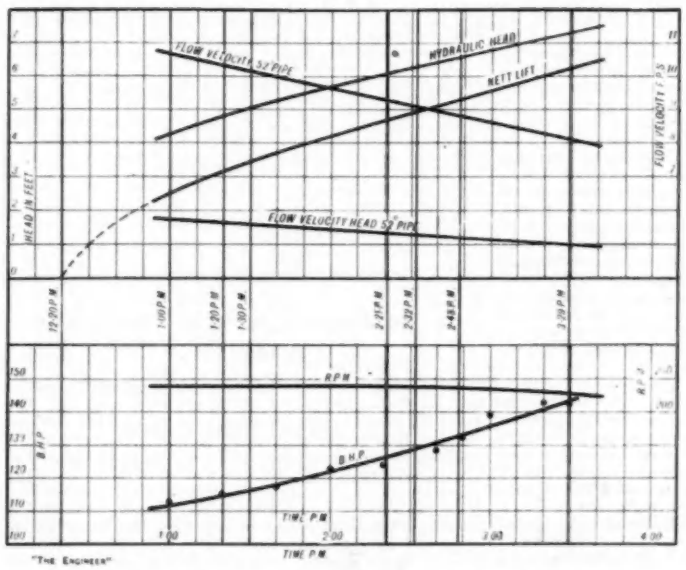
"THE ENGINEER"

FIG. 3



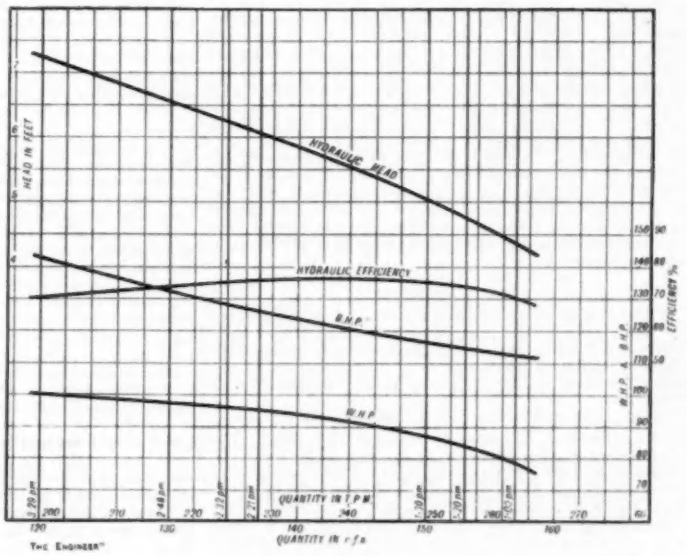
"THE ENGINEER"

FIG. 4



"THE ENGINEER"

FIG. 5



THE ENGINEER"

FIG. 6

on four wheels; if over, on six; and it had to draw three times its own weight at 10 miles an hour on the flat.

Ten engines were said by the *Mechanics' Magazine* to have been in preparation, but only four appeared, together with a horse machine. Those which actually faced the starter were described on the "race card" as follows:—

No. 1.—Messrs. Braithwaite and Ericsson's "Novelty."
2.—Mr. Hackworth's "Sans Pareil."
3.—Mr. Stephenson's "Rocket."
4.—Mr. Brandreth's "Cyclopede" (horses).
5.—Mr. Burstall's "Perseverance."

The "Rocket."

To take the "Rocket" first. It was entered by George and Robert Stephenson, and Henry Booth. Although George has always been popularly credited with the design, it was Robert to whom it was principally due; the father's time being fully occupied with the making of the railway.

Booth, who was the secretary and treasurer of the line, suggested the tubes in the boiler, which appear to have been quite an independent idea of his, though Seguin was actually constructing an engine with tubes at the time in France. To Booth we also owe the screw coupling, one of which is shown on his statue in St. George's Hall, Liverpool.

The earliest published illustration of the "Rocket" was given in the *Mechanics' Magazine* for October 24th, 1829. On November 29th, another appeared, in which some trivial inaccuracies were said to be corrected. Both were probably drawn by C. B. Vignoles, the engineer.

The exact form of the fire-box has been a matter of some uncertainty, as the *Mechanics' Magazine* drawings do not quite agree with those in Wood's "Treatise on Railroads," which contained illustrations, differing between themselves, in the second and third editions. But there is now a fresh witness to call. The author has had the extraordinary good fortune to discover, and acquire, Rastrick's own notebook, which he used at the trials. The most important page dealing with the "Rocket" has a sketch showing the fire-box with a square corner, and a dry back. Wood says it had a water space at the back,[2] but Rastrick seems to have been the one who took the particulars down.

The general design followed that of its predecessor, the "Lancashire Witch," the principal differences being the substitution of a small pair of trailing wheels for a pair coupled to the drivers, and, of course, the tubular boiler. The wheels were 4ft. 8½in. and 2ft. 6in. respectively. The cylinders, which were inclined at an angle of 35 deg., were 8in. diameter by 17in. stroke. The evidence about the latter is conflicting, as Rastrick says it was 16½in.; the figure also given by Wood, who probably trusted to him. It is remarkable that he should have made a mistake in measuring such an important dimension, but there seems no escape from this conclusion, as the wheels now on the engine have a 17in. stroke, and have every appearance of being the original ones. The latter figure is also given in a "description book," as it is called, of Messrs. Stephensons', dated 1831. The boiler, which was 3ft. 4in. in diameter, and 6ft. long, contained twenty-five copper tubes, 3in. diameter; working pressure, 50 lb. per square inch. There were two exhaust outlets in the chimney, one for each cylinder.[3] The weight in working order was 4½ tons; 2 tons 12 cwt. 1 qr. on the driving wheels; and 1 ton 12 cwt. 3 qr. on the trailers.[4]

The "Rocket" is still with us. Subsequently to the competition the cylinders were lowered to a nearly horizontal position. It was employed on the Liverpool and Manchester Railway until 1836. A minute of the directors dated October 24th in that year records that it was sold to Mr. James Thompson, of Carlisle, for £300. It worked in the Midgeholm Colliery until 1844, and was handed over to the South Kensington Museum in 1862. The fire-box has disappeared.

The "Novelty."

The "Novelty," which was built in London, was entered by John Braithwaite and John Ericsson. Braithwaite afterwards became engineer to the Eastern Counties Railway. Ericsson emigrated in 1839 to the United States, and afterwards became famous as the builder of the "Monitor."

We have again a contemporary illustration of the engine in the *Mechanics' Magazine* for October 17th, 1829. The wheels were 4ft. 2in. diameter, on the suspension principle, patented in 1826 by Theodore Jones. They are still in existence, at the South Kensington Museum. The cylinders, which have also survived, are 6in. by 12in. They were vertical, and drove through bell-cranks to a crank axle; the first used on a railway engine. Barton's pistons, with metallic packing, were used.[5] The boiler, the barrel of which was 13in. diameter by 10ft. long, contained a small tapering flue, which returned on itself twice. The fuel was introduced through the top of the fire-box. Air was forced into a closed ashpan by bellows worked by the engine. The weight in working order was 3 tons 17 cwt. The fuel and water were carried on the engine, so that no tender was required.

The "Novelty" was not purchased by the directors, though it worked on the Liverpool and Manchester Railway to some extent, afterwards being used on the St. Helens, and on the North Union Railways.

"The Sans Pareil."

The "Sans Pareil" was produced by Timothy Hackworth, the engine superintendent of the Stockton and Darlington Railway. Besides the engine itself, the South Kensington Museum possesses a coloured drawing of it as first built. The wheels were 4ft. 6in. diameter, coupled. The boiler was 4ft. 2in. diameter by 6ft. long, with a return flue; the grate and chimney being at the same end. Some of the early illustrations of this engine err in putting the tender at the wrong end. The cylinders, 7in. by 18in., were vertical, and inverted over the trailing wheels. The weight in working order was 4 tons 15 cwt. 2 qr., and was over the 4½ which was prescribed as the limit for four wheels; however, the trial was allowed to proceed.

The "Sans Pareil" was bought by the directors for £550, and let on hire to the Bolton and Leigh Railway, being sold outright to that line in 1832 for £110, where it worked until 1844. It was then used at a colliery for pumping until 1863, when the mine became exhausted, and it was restored to the original form and presented to the Museum.

The "Perseverance."

The "Perseverance" was entered by Timothy Burstall, of Leith. Its feeble performance caused it to be almost completely ignored in all the descriptions, but there is now no doubt that it is represented by an old lithograph which has been recently discovered, and shows it with four equal uncoupled wheels and a vertical cylinder (probably two) driving, by means of return connecting-rods, a countershaft which turned the axle by gear wheels.

Burstall had built a steam road coach with the boiler at the back in 1824. In 1826 he took out a patent for a six-wheeled coach with the boiler carried separately from the body. Luke Hebert, in a supplement to Galloway's "History and Progress of the Steam Engine," 1831, illustrates the first coach, and a model of the second. He states that the "Perseverance" was similar to the coach described on the page showing the first one. But the *Mechanics' Magazine*[6] gives a description which points rather to the second as its prototype, and as Hebert gives two other wrong references to pages immediately before and after this one, it is practically certain that he meant to indicate the second coach, and not the first; which would be in accord with the illustration that has now come to light.

The subject is discussed at greater length, with some further evidence, in the author's book[7] recently published.

No dimensions are known, except the weight, which was 2 tons 17 cwt. Like the "Novelty," it carried its own fuel and water.[8]

The only remark of interest made by Wood on the subject is that the boiler consisted of an upright generator, "the heated air and flame escaping up the chimney immediately from the fireplace, without any flues to abstract the redundant heat."[9] Rastrick's note-book does not mention the engine.

The "Cyclopede."

The "Cyclopede" was an absurd affair, entered by T. S. Brandreth, of Liverpool. It was worked by a horse moving an endless platform with his feet. All the representations of it appear to have been copied from one in Galloway's "History and Progress of the Steam Engine," and only show one horse, but the machine exhibited at Rainhill had two. The weight was given as 3 tons.

The Judges.

Three judges were appointed, namely, Nicholas Wood, of Killingworth; John Urpeth Rastrick, of Stourbridge; and John Kennedy, of Manchester. Wood was the chief engineer at the Killingworth Collieries, and had therefore had no less than fifteen years' experience of locomotive work. He was the author of the standard work of the period on railways.

Rastrick was in partnership with William Foster in a steam engine factory at Stourbridge, where four locomotives were built about this time, three of which went to America, while the other, the "Agenoria," worked near Stourbridge for nearly half a century, and now rests in the South Kensington Museum.

Kennedy was a cotton spinner and inventor, the originator of some improvements in spinning machinery. It does not appear from either Wood's or Rastrick's account that he took a very active part in the trials.

The Trials.

The first day of the competition was Tuesday, October 6th, the place being a level stretch at Rainhill, about 9 miles from Liverpool. The engines ran forwards and backwards over a mile and a-half, one-eighth of a mile being allowed at each end for starting and stopping.

A grand stand was erected, which contained the beauty and fashion of the neighbourhood. There was also a great concourse of engineers from all over the country.

Tuesday, October 6th.—The first runs were made by the "Rocket," which drew 12 tons 9 cwt. at the rate of 12 miles an hour,[10] running light at about 18,[11] or, according to another account, 24,[12] and with a load, including passengers, of 13 tons at 15 miles an hour.

The "Sans Pareil" made a trip, light.

Mr. Brandreth's horse-locomotive also showed its paces, "not in the way of competition, but as exercise. About fifty persons clung round the wagons, giving a gross weight with the machine of about five tons, and with this weight, the horses (themselves moving scarcely one mile and a-quarter an hour) propelled the wagons and load exactly at the rate of five miles an hour."[13]

The sensation of the day was provided by the "Novelty," which attained 28 miles an hour without load, and caused great excitement. There was also a demonstration of a "manumotive" carriage invented by Winans, which was propelled by two men, and carried six passengers. We are informed that it moved "with no great velocity."

Wednesday, October 7th.—The "Novelty" opened the proceedings, and did one trip loaded at 20¾ miles an hour, after which the bellows burst. The weather was very bad, and nothing more was done on that day, except a few exhibition runs.

Thursday, October 8th.—This morning a surprise was in store for the competitors, as they were handed a small card containing new conditions, the judges having come to the conclusion that the original ones were not sufficently definite. The chief point about the "ordeal" as it was called, is that the engines were required to run 70 miles practically continuously, at an average of not less than 10 miles an hour.

The serious business of the competition now began, the "Rocket" starting off at 10.36, and completing the required distance without a hitch, at an average of about 15 miles an hour, the greatest speed being over 29. The consumption of water was 114 gallons and of coke 217 lb. per hour.

The performance all day was wonderfully consistent, and Rastrick records that at the conclusion the steam was as "strong" as at the commencement, namely, 50 lb. per square inch.

Friday, October 9th.—On this day nothing seems to have taken place.

Saturday, October 10th.—The "Novelty" came up for trial. On the very first trip the feed pipe burst, owing to the engineman having closed a cock between the pump and boiler. While it was being repaired, the "Rocket" did two runs without the tender, at 30 miles an hour. In the afternoon the "Novelty" did some exhibition runs much to the delight of the company; in one of which it took a carriage with about forty-five ladies and gentlemen at 30 miles an hour.

Tuesday, October 13th.—Nothing was done on the Monday. The "Sans Pareil" came forward, and started on the allotted task. On the eighth trip the pump ceased to work, causing the water level to fall, and the lead plug to melt. Rastrick says that the plug was replaced, and steam got up, but the force pump went wrong again, and the further prosecution of the experiment was abandoned. The speed was about 14 miles an hour, with a maximum of 16½. The consumption was worked out by Wood at 150 gallons of water and no less than 692 lb. of coke per hour.

Wednesday, October 14th.—On this day the "Novelty" again faced the starter, but on the second trip a boiler joint blew out; it was said, owing to the cement not having had time to set, and the owners withdrew.

The "Perseverance" then made some "experimental" trials, but appeared to be only capable of 5 or 6 miles an hour, and was also withdrawn. This engine may also have been handicapped by a hasty repair, as it appears that they let it fall when unloading it, which injured one of the cranks, and broke a pipe,[14] and probably strained it generally.

The prize was awarded to George and Robert Stephenson and Henry Booth, a consolation prize of £25 being given to Burstall.[15]

The actual report made by the judges to the directors has not come down, but the tenor of it is obvious. Only one of the starters stayed the course.

The result of the trials was to establish the locomotive in an unrivalled position as the motive power of the future, and not solely on the ground of speed. Rainhill was situated between two inclined planes of 1 in 96, known as Whiston and Sutton, and there is no doubt that the ease with which they were climbed by the locomotives, especially by the "Rocket," led to the abandonment of the stationary engines which had previously been thought essential at these two places.

No contemporary illustrations of the scene have been found. A small woodcut in Smiles' "Lives of George and Robert Stephenson," which has been copied by subsequent writers, was evidently drawn for the book, from imagination. Another sketchy representation is known, but the copies seen by the author certainly do not go back to 1829.

No medals were struck to celebrate the occasion, as was the case in the following year, when the railway was opened. Some Staffordshire pottery, mugs and jugs, decorated with the engines, are occasionally found. Strange to say, none are known of the "Rocket," though they must surely have been made, as the "Sans-Pareil" and the "Novelty" both exist, several examples of the latter being known.

References.

[1] Minutes of directors, L. & M.R., April 20th, 1829.
[2] Wood's "Treatise on Railroads," third edition, page 324.
[3] *Ibid.*, page 511; Robert Stephenson's statement in Smiles' "Lives," edition of 1862, page 503.
[4] Rastrick's notebook.
[5] Hebert's "Practical Treatise on Railroads," 1837, page 144.
[6] *Mechanics' Magazine*, Vol. XII., page 163.
[7] "Two Essays in Early Locomotive History," Locomotive Publishing Company, London, 1928.
[8] *Liverpool Times*, October 13th, 1829.
[9] Wood, third edition, page 330.
[10] Rastrick's notebook.
[11] *Mechanics' Magazine*, Vol. XII., page 115.
[12] *Liverpool Courier*, October 7th, 1829.
[13] *Ibid.*
[14] Minutes of directors, October 5th, 1829.
[15] *Ibid.*, October 20th, 1829.

A Portable Electric Harmonic Analyser.

At the meeting of the Institution of Electrical Engineers held on March 21st, at which papers were read on "The Direct Generation of Alternating-current at High Voltages and on Recent Developments in Turbo Generators," a portable electric harmonic analyser was exhibited. The operation of the analyser, which is described in a short paper by Mr. R. Thornton Coe, depends on the elementary principle of the dynamometer or wattmeter, that a steady reading is produced only by components of current in the fixed and moving coils, which have the same frequency. Thus a small current having an R.M.S. value of about 0·02 ampère and obtained in some known way from the voltage or current to be analysed is passed through the moving coil of such an instrument, while through the fixed coil is passed a sinusoidal "analysing current" having exactly the same frequency as any particular harmonic which it is required to find.

The phase of the analysing current can be adjusted to bring it into phase with the required harmonic in the moving-coil current; under these conditions the dynamometer reading becomes a maximum and is given by the very simple relation

$$D_{max} = k\, I_a\, I_n \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where k = d.c. calibration constant of dynamometer.
I_a = analysing current in ampères (R.M.S.), and
I_n = required nth harmonic in the moving-coil current, in ampères (R.M.S.).

The required nth harmonic in the moving-coil current is therefore given by

$$I_n = \frac{D_{max}}{k\, I_a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The analysing current I_a is measured on a thermal-type ammeter, and, since k is a known constant, I_n can readily be calculated.

The Analysis of a Voltage Wave.

A given voltage is analysed by connecting it through a suitable external series impedance to the moving coil of the dynamometer. For the analysis of alternator voltage-waves, in which the harmonics are usually small compared with the fundamental, this external impedance consists

of a condenser in series with a non-inductive resistance, as, for a given R.M.S. current, this combination gives for the higher harmonics considerably larger dynamometer readings than a resistance alone.

The total impedance of the moving-coil circuit to the nth harmonic current can be calculated from its known constants. If its value in ohms be denoted by Z_n then the required nth harmonic in the applied voltage wave is given in R.M.S. volts by

$$V_n = Z_n I_n \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

From equations (1) and (2) it is easy to calculate over the whole range of harmonics a curve giving the dynamometer deflection for a 1-volt harmonic in the applied voltage, and for a full-scale value of the analysing current. With such a curve as is shown in Fig. 1, the magnitudes of the various harmonics can be calculated with extreme

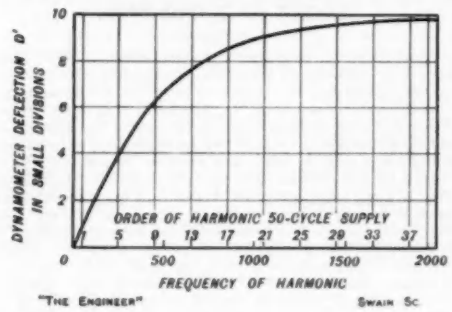


FIG. 1

Typical calibration curve giving dynamometer deflection D′ for a 1-volt harmonic and with 100 mA of analysing current.

rapidity from the corresponding readings of the dynamometer and thermal ammeter.

The deflections for the higher harmonics are such that on a voltage wave at about 100 volts the harmonics can be measured to within 0·05 per cent. of the fundamental, while very small harmonics can be measured to within 0·01 per cent. of the fundamental.

The magnitude of the fundamental component of the voltage is obtained from its R.M.S. value, as measured on a suitable voltmeter, and the magnitudes of the various harmonics found to be present.

ANALYSIS OF A CURRENT WAVE.

To analyse a current wave the dynamometer moving-coil is connected directly across a suitable shunt carrying the given current. For a current wave which is considerably distorted from sine-wave form, a non-inductive shunt is suitable, and in this case the distribution of current between the shunt and the moving coil can be calculated from their relative resistances, the ratio of the shunted current to the main current being the same for all harmonics. Harmonics down to 0·2 per cent. of the fundamental can be measured, for a voltage drop of about 2 volts in the shunt.

If the harmonics in the current wave are very small, increased accuracy for a given voltage drop can be obtained by using an inductive shunt.

The fundamental is determined from the R.M.S. value of either the total or the shunted current, as measured on

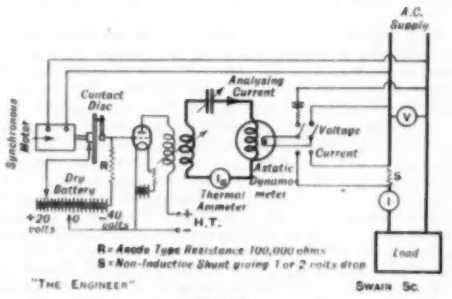


FIG. 2

Diagram of connections for electric harmonic analyser when arranged for simultaneous analysis of voltage and current waves.

a suitable ammeter, and the magnitudes of the harmonics found to be present.

MEASUREMENT OF PHASE ANGLE BETWEEN HARMONICS OF THE SAME FREQUENCY IN TWO DIFFERENT WAVES.

The dynamometer moving-coil is first supplied from one wave and the phase of the analysing current adjusted to give zero deflection of the dynamometer. By means of a throw-over switch it is then supplied from the second wave, and the deflection, say, d_1, noted. The phase of the analysing current is then further adjusted to give a maximum reading D_{max}, the magnitude of the analysing current being maintained constant.

Referred to their own period, the phase angle between the two resulting harmonics in the moving-coil current is given by

$$\varphi = \text{arc sin} \frac{d_1}{D_{max}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

This is the required phase angle if two voltage harmonics or two current harmonics are being compared; but if the phase angle between a voltage harmonic and a current harmonic is to be found, allowance must be made for the fact that, for the former, the harmonic in the moving-coil current leads the harmonic of applied voltage by a phase angle which can be calculated from the known constants of the moving-coil circuit.

PRODUCTION OF SINUSOIDAL ANALYSING CURRENT.

The chief feature of the apparatus is the method of producing the analysing current which must be as nearly as possible sinusoidal and have exactly the same frequency as the required harmonic. These requirements are met by the use of a special contact disc and a valve circuit, as shown in Fig. 2.

The contact disc, the face of which consists of a number of concentric rings of insulating and conducting segments, is driven by a small synchronous motor from the alternating-current supply which gives the wave-form to be analysed. One ring of contacts is used for each harmonic. The alternate insulating and conducting segments in each ring are of equal width and sufficient in number to give the frequency of the corresponding harmonic. Provision is normally made on one disc for all the odd harmonics up to the thirty-fifth, but any others can be arranged for on interchangeable discs as required.

Contact with the disc is made through a fixed brush on the motor spindle and a movable brush on the disc face. The movable brush is so arranged that it can be set on the ring of contacts for any required harmonic, and can also be rocked, concentric with the axis of the disc, in order to alter the phase of the analysing current. By means of a grid battery and a high resistance leak, connected as shown in Fig. 2, the opening and closing of a circuit by the contact disc are made to apply to the grid of a valve an alternating voltage having the frequency of the required harmonic. An E.M.F. of the same frequency is induced in a final closed circuit by an anode coupling of the valve, and the analysing current is obtained in this circuit when tuned to the given frequency. The tuned circuit, which has a fairly high resistance, is only used to improve the wave-form of the analysing current and so the tuning need not be exact.

Both instrument readings are steady, even when the supply frequency is fluctuating, this being one of the chief advantages of the analyser.

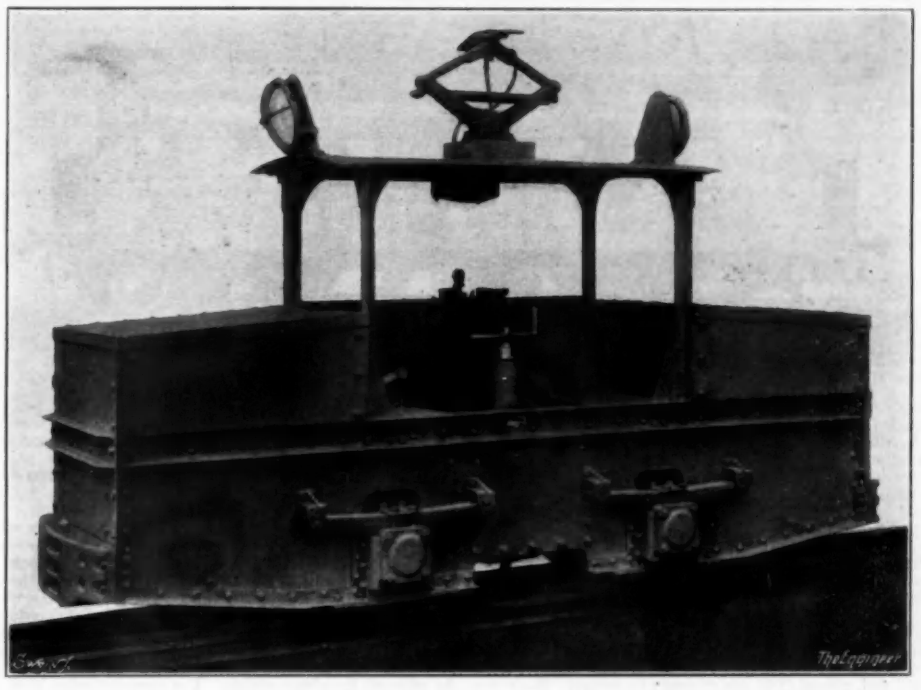
Fig. 2 shows the connections of the analyser when arranged, as at the demonstration, for the complete investigation of a load circuit, including measurements of the harmonics in the supply voltage and in the load current, and phase angles between corresponding harmonics in the two waves.

A number of results of typical tests made with the analyser were shown at the demonstration in the form of analyses of alternator voltage-waves, accompanied by their oscillograms. In some cases the analyses of the waves have been carried up to the forty-ninth harmonic.

The method of harmonic analysis described is a perfection of the dynamometer method which was described in a paper by J. D. Cockcroft, R. T. Coe, J. A. Tyacke, and Professor Miles Walker, read before the Institution of Electrical Engineers four years ago.

ELECTRIC MINE LOCOMOTIVE

GREENWOOD AND BATLEY, LTD., LEEDS, ENGINEERS



Electric Mine Locomotives for the Far East.

THE illustration above represents one of seven electric locomotives which have recently been made by Greenwood and Batley, Ltd., of Leeds, for a coal mine in the Far East.

They are designed to run on a track of 18in. gauge composed of 25 lb. rails, and have a wheel base of 3ft. 6in. The overall dimensions, which were determined by the size of the pit cages, are 10ft. 3in. long by 2ft. 9in. wide. Their service will be to draw trains of about 60 tons, made up of forty tubs of coal and five tubs of stone at a speed of 6½ miles per hour. The specified drawbar pull is 2000 lb., but on test a maximum pull of 3000 lb. was registered, and that effort can be exceeded by taking on board extra ballast, for which appropriate lockers are provided.

Each locomotive is equipped with two totally-enclosed weather proof motors of 18 to 20 H.P. on a one-hour rating, working at 550 to 600 volts. The drive is transmitted from the motors—one of which is connected to each axle—through gearing consisting of a nickel steel hardened and ground worm and a phosphor bronze worm wheel, giving a reduction of approximately 8 to 1. The casing of the worm gear forms a dust-proof housing and the gear is run in an oil bath. The current is collected from the overhead line by a spring loaded reversible pantagraph collector, and is conducted through a traction type circuit breaker to a tramway type controller. This controller gives seven running speeds in either direction, and, in addition, two braking notches.

The main frame is built-up of rolled steel sections, and is provided with machined guides for the axle boxes. There are combined buffers and towing hooks giving three coupling positions. Ball and roller bearings are fitted throughout and all the bearings are enclosed in dust-proof housings. Cast iron shoe brakes are fitted to all four wheels, and are operated by a balanced mechanism from a handle in the driver's cab. The latter, it will be seen, is in the centre. It has seats so arranged that the driver can face in the direction of travel and have an uninterrupted line of vision. Powerful headlights are fitted in the roof of the cab.

The approximate weight of the locomotives in running order is 4 tons, and provision is made for carrying an additional ton of ballast.

Power Development on the Kootenay River.

DURING recent years great strides have been made by the West Kootenay Power and Light Company, Ltd., in hydro-electric development in the Nelson District of British Columbia, where there is an ever growing demand for electrical energy for use in mining and smelting and for the operation of pulp and paper plants. At present the company is developing a site at South Slocan on the Kootenay River, where turbines totalling 75,000 H.P. are being installed.

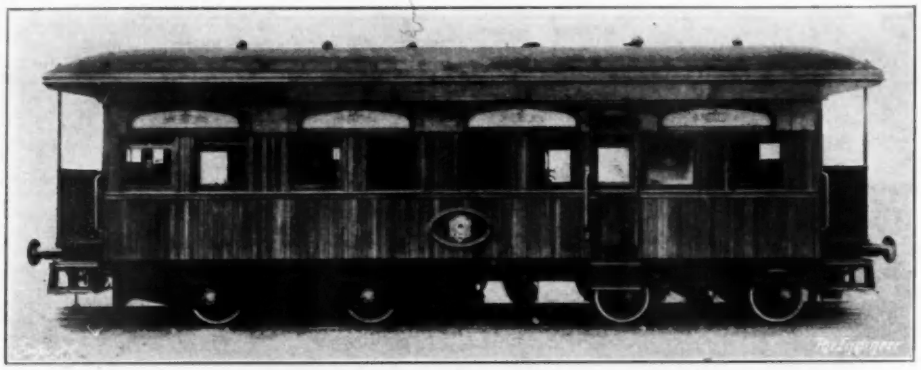
Of outstanding interest is the company's development at Lower Bonnington Falls, also on the Kootenay River. This plant, which has a total rating of 60,000 H.P., is situated at the north side of the Kootenay River, about eleven miles downstream from the City of Nelson. The head obtained at this site averages about 60ft., but varies from 56ft. to 70ft. during the different seasons of the year. The minimum discharge occurring in the latter part of the winter is about 6000 cubic feet per second, while during June and July, under flood conditions, a discharge of 150,000 cubic feet per second is not unusual.

The generating station is built on the site of an old power-house, which was completed in 1897, to generate 4000 H.P., under a 37ft. head, to supply power to the then flourishing mining camp at Rossland. At a later date the Consolidated Mining and Smelting Company, Ltd., acquired F. Augustus Heinze's interest in the Trail smelter, and electrified the plant. Then, in 1905, owing to the further development of the Boundary country by the Granby Company and the British Columbia Copper Company, No. 2 hydro-electric development at Upper Bonnington Falls, having a capacity of 32,000 horse-power, was erected. Thereafter it was found necessary to develop further Lower Bonnington Falls to 60,000 horse-power hydraulically, to take care of the ever-increasing demands of the Consolidated Mining Company, and in order to develop Lower Bonnington to its full capacity it was necessary to wreck the 4000 horse-power plant erected in 1897.

Preliminary work included removal of this old structure. A permanent spur line for delivery of materials and machinery to the power house site from the Canadian Pacific Railway was then constructed. This line extends into the north end of the generator room, and serves the generating station, switch house, and outdoor transformer station for convenient handling of equipment. Sleeping quarters and dining-rooms with accommodation for 450 men, and shops for carpenters and machinists were built,

RAILWAY MOTOR COACH

DREWRY CAR COMPANY, LTD., LONDON, ENGINEERS



and a compressor plant for the supply of air for rock was installed.

A cribwork dam, extending across the river from the entrance to the intake canal, was built to back water up one mile to the tail-race of the power plant at Upper Bonnington Falls. This dam stabilises the head of the lower plant during low water. Considerable rock work, to improve the flow of water in the river below the power-house, was carried out during the low water period.

The power-house substructure, built as a unit, with the headworks dam on solid rock, is of reinforced concrete. In general dimensions it is 162ft. long in the direction of stream flow, 153ft. wide, and 111ft. high from the floor of the draught tubes to the top of the headworks dam. Provision was made for three generating units designed to develop 20,000 horse-power, at 100 revolutions per minute, under 70ft. head, placed 50ft. apart centre to centre. Each penstock entrance has two rectangular water passages, 14ft. 6in. wide separated by a 6ft. wall. These passages come together before entering the steel plate spiral casing, which guides the water to the turbine wheel entrance. The spiral casing is 23ft. in diameter. The water entrances are provided with motor-operated Stoney head gates, and recesses for stop logs.

In case of emergency, should it be necessary to shut off water to the turbine wheel, the gates for each unit can be released and dropped from the generator room floor. The tripping device is operated by compressed air, and control valves are mounted on the main switchboard. The entrances to the penstocks are protected by removable inclined trash racks which are cleaned by a travelling gantry type of cleaner.

The maximum velocity of the water passing through the intake canal is about 2ft. per second, and very little loose rock or floating material will be diverted into it from the river. Water for the transformer pumps, fire pumps, station toilets, &c., is taken from the forebay just in front of the stop log checks. It passes into a pump at the north side of the headworks dam, and thence through the pipes to the required position. Each draught tube is divided into two water passages, 14ft. 6in. wide at the water outlet, by a wall 6ft. wide.

Stoney gates, operated by an electric travelling gantry crane, are provided to shut off water to the draught tubes from the tail-race, and a pump for draining the tubes, to facilitate repair work on the turbines, capable of discharging 14,000 imperial gallons per minute against a 56ft. head has been installed. This pump is interconnected by pipes with the three draught tubes.

The generator room floor is 210ft. long by 46ft. wide, with space provided at the north end for the main switchboard, and for assembling machinery. Cooling air for the generators is obtained in winter through gratings in the floor, and in summer through intakes from outside. Air cleaners are provided for all intakes, The main run of conduit ducts is embedded in concrete just below the floor. Crane and roof loads are supported by a steel framework with columns built into the reinforced side walls. Roofing is five-ply Barrett specification type laid on laminated 2 by 6 timber.

The switching-house is separate from but close to the generator room. It contains two stories, its overall dimensions being 80ft. by 21ft. 6in. by 30ft. high. Floors and walls are of reinforced concrete. The transformer station is of the modern outdoor type, with concrete foundations, and steel overhead structure. It is situated on rising ground, about 500ft. downstream from the generating station.

The equipment installed includes three turbines of 20,000 horse-power at 100 revolutions per minute, and 70ft. head with vertical shafts, direct connected to the generators. The runners are of cast iron. The inlet diameter is approximately 120in., with a maximum diameter of approximately 160in. The guide vanes are of cast steel, and the regulating mechanism is mounted on the cover plate. The main turbine bearings are of the adjustable *lignum vitæ* type.

Motor Coach for Argentina.

A HANDSOME motor-driven railway coach, which has recently been supplied to the Buenos Aires Great Southern Railway by the Drewry Car Company, Ltd., of 13, Southplace, London, E.C. 2, is illustrated by the engraving above. It is intended for the personal use of the chief engineer and his staff on extended tours of inspection, for which purpose a motor coach is, obviously, very convenient, as it can be got ready for a journey at short notice and requires little attention when not running.

As will be seen from the engraving, the vehicle is of the bogie type and all the machinery is concentrated on one of these bogies. The body includes a saloon, with two convertible berths, a bathroom, a kitchen and a servants' compartment. At each end there is an observation platform.

It is driven by a six-cylinder petrol engine of 100 horse-power, which has cylinders 5½in. in diameter by 6in. stroke and runs at 1000 revolutions per minute. The gear-box casing is of aluminium and contains gears which give speeds of 7, 15, and 35 miles per hour when the engine is running at its normal speed. The gear wheels are machine cut, case-hardened and ground where necessary. The changes are effected by sliding the gears as in a motor car. From the gear-box the drive is transmitted to a reversing gear through a set of bevel wheels and sliding dogs, so that the three speeds can be used in either direction. The drive from the reversing box to the driving wheels is effected by silent chains. The sprocket wheels on the main axle are of cast steel and are made in halves, so that they can be easily renewed. Provision is made for adjusting the chains by means of parallel motion.

The framing of the power bogie is of the locomotive type, built up of steel plates, and is provided with an inner frame to carry the engine and gear-box. The carrying bogie is of the American diamond frame type, and the main frame of the body is of steel channels. The wheels are of the solid forged Newlay type, 2ft. 6in. in diameter by 5½in. wide, and the journals are 4in. in diameter by 8in. long. There are brakes on all the wheels and they are operated by hand screw gear and a foot pedal through compensating gear.

There are control stations at each end of the coach, and the control rods are all carried to the centre of the frame, where they are connected with the power bogie by universal joints. A comfortable seat is provided for the driver. The tanks are of welded steel and comprise one supplementary water tank of 20 gallons and two petrol tanks holding 30 gallons. The petrol tanks are interconnected, but so arranged that they can be worked independently. There are radiators, of the tubular type, at each end of the coach. Electric light is provided by a C.A.V. dynamo driven directly by the engine. There is an additional dynamo and battery supply current for the electric self-starter.

The exterior of the body is matchboarded with teak, varnished, and the interior lined with pitch pine. The approximate weight of the coach in running order, without passengers, is 20 tons.

B.E.S.A. SPECIFICATIONS.

SYNTHETIC RESIN VARNISH PAPER BOARDS AND TUBES.

THE British Engineering Standards Association has just issued a new specification, No. 316, 1929, which applies to Synthetic Resin Varnish Paper Boards and Tubes for general electrical purposes, excluding tubes moulded after being rolled, and also a revision of B.S.S. No. 229, Flame-proof Enclosures for Electrical Apparatus. The provisions of B.S. Specification No. 316, 1929, are confined to what is termed Grade II. material, *i.e.*, synthetic resin varnish paper boards and tubes, the principal characteristic of which is high electric strength at high temperature. This grade of material is suitable for use on high-voltage, oil-immersed plant and on low-voltage apparatus in air. The specification does not at present apply to Grade I. material, which is defined as including boards and tubes, the principal characteristics of which are relatively low water absorption, high resistivity, low dielectric losses at radio frequencies and good machining properties. This material is such as is required for use on apparatus where it is important that high insulation resistance shall be maintained under all conditions of humidity. The specification will be extended at a later date to cover Grade I. materials, but further research work is necessary before an adequate specification for this grade can be drafted. The specification lays down suitable working limits for the materials to which it applies. A series of appendices supplies detailed instruction for the carrying out of the necessary tests, and there are two appendices giving abridged schedules of tests recommended for application to boards and tubes intended for certain specific uses.

FLAME-PROOF ENCLOSURES.

B.S.S. No. 229, 1929, Flame-proof Enclosures for Electrical Apparatus, defines the performance required for such enclosures, and the tests to be carried out to verify such performance. The special features of design and construction of apparatus are specified in the several British Standard Specifications dealing with particular flame-proof apparatus. This specification, which is a revision of the 1926 edition, embodies the results of experience in testing which has been gained since the issue of the original specification. Provision is now made for preliminary observation tests, and the number of tests to be performed is indicated.

Both the above specifications and the methods of test given therein are based on information supplied by the British Electrical and Allied Industries Research Association, and represent the results of a considerable amount of research work carried out by the Association. Copies of the above Specifications may be obtained on application to the Publications Department, British Engineering Standards Association, 28, Victoria-street, London, S.W. 1, price 2s. 2d. each post free.

BOOKS OF REFERENCE.

"LOCOMOTIVE Engineer's Pocket Book," 1929. London: The Locomotive Publishing Company. 1929. Price 3s. 6d.—This annual volume enjoys the advantage that it is devoted to one subject. Hence it is able to cover it with reasonable fulness without exceeding the dimensions and weight of a volume that can be slipped into the pocket though it is a little taller and stouter than it used to be. From a long knowledge of it we may say that it has always been a very comprehensive book, and that in successive years it has kept pace with developments. There is no more useful work of reference for the locomotive man, for there is hardly a subject connected with the general features of locomotives that is not dealt with, even down to running-shed matters. It is frequently very desirable to have general ideas of weights, dimensions, and so on. There are plenty of such figures in this pocket-book, as well, of course, as formulæ to enable accurate calculations to be made. As a little book for ready reference we know of none handier.

"THE South African Mining and Engineering Year Book and Directory," which is published in this country by Argus South African Newspapers, Ltd., 72–78, Fleet-street, London, E.C. 4, price 22s. 6d. post free, appears in the 1929 edition in the fifteenth year of issue. The present volume seems to be even more informative than those which have preceded it. It contains, first of all, a directory section which embodies a list of the principal firms in the engineering, electrical, iron, steel, machinery and hardware trades throughout the Union of South Africa, Rhodesia, South-West Africa, &c. Then there is a list of consulting engineers and geologists, which is followed by a list of buyers of goods for various interests. Then there are lists of mining and industrial companies; of mines in Rhodesia and South-West Africa; of overseas manufacturers represented in South Africa, with their leading products; and of British and overseas manufacturers and exporters to South Africa. Next comes a buyers' guide to mining and engineering specialities, which is followed by an extensive gallery of portraits of leaders in South African mining, engineering and industry. The remainder of the book is taken up with a mass of information regarding industries of every sort and kind in the southern portion of the African continent, which are too numerous to particularise, all of which forms most interesting reading.

THE INSTITUTE OF TRANSPORT.

THE eighth congress of the Institute of Transport will be held at Harrogate, covering the period Thursday to Saturday, May 9th to 11th. The headquarters of the congress will be at the Grand Hotel. The following provisional order of proceedings has been prepared:—

On Thursday, May 9th, at 9.30 a.m., the President will open the congress at the Grand Hotel and the Mayor of Harrogate will extend a civic welcome to the delegates. The following papers will then be considered:—"The Characteristic Features of the Transport Facilities of the North-Eastern Area of the L.N.E.R.," by Thos. Hornsby, Divisional General Manager (North-Eastern Area), L.N.E.R.; and "Influences Affecting Transport Development and Efficiency," by Major E. G. E. Beaumont, O.B.E. (Member). In the afternoon there will be alternative visits to (A) the headquarters and the wagon and carriage works of the L.N.E.R., and the Railway Museum at York; (B) the works of Rowntree and Co., Ltd., at York; and (C) the works of John Fowler and Co., Ltd., at Leeds.

On the Friday morning the following papers will be discussed:—"Trade and Transport Prospects on the North-East Coast," by R Bell, C.B.E., Assistant General Manager, L.N.E.R.; and "Internal Air Services and Overseas Connections," by Colonel I. A. Edwards, C.M.G. In the afternoon there will be alternative visits to (D) the locomotive works of the L.N.E.R. at Darlington; (E) the works of the Airship Guarantee Company, Ltd., at Howden, to view the new airship R 100; and (F) a tour by road to Pateley Bridge, Brimham Rocks, and Fountains Abbey.

For the Saturday the following alternative visits have been arranged:—(G) the Aire and Calder Navigation and the port of Goole; and (H) a tour to Whitby and Scarborough by road and rail.

AMONG the uses requiring chromic acid are the manufacture of electric batteries, photography, etching of copper, bleaching, &c. By far the larger part of the consumption, however, is in electro-plating and in the tanning industry. Sodium or potassium bichromate is used in the manufacture of pigments; chrome yellow is produced by treating either the sodium or potassium bichromate with acetate of lead or some other soluble lead salt. Various shades of yellow are produced by varying the chemical proportion of these elements. "American vermillion," used largely as a substitute for artificial or manufactured cinnabar, is a basic lead chromate, made by dissolving chrome yellow in caustic soda. Chrome green is manufactured by mixing chrome yellow with Prussian blue and is used in the manufacture of lithographic inks.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Market Activity.

DEMAND alike for iron and steel continues to grow. The gradual expansion of consumptive requirements of Midlands and Staffordshire works is such, however, that manufacturers, except in rare cases, see no need to place long date contracts for material. They are satisfied in their own minds that the best policy at present is to buy iron and steel as they need it week by week or month by month. Many of them cherish the belief that they will be able at some future date to buy pig iron on terms more favourable than the control now offers. There appears little to support this theory in the recent trend of events in this department, but consumers, though admitting the solidity of smelters at the moment, doubt their ability to hold together when supplies become in excess of demand. How they reconcile themselves to the hand-to-mouth policy of buying in steel it is more difficult to determine, for an increase in official prices of finished steel would not occasion any surprise; indeed the action of the Steelmasters Association in re-declaring the official basis in face of increased production costs created some wonder. Steel semis have been advancing in price for some time now, and it would be unwise to predict that peak values have been reached in this branch of the steel trade. As Midland manufacturers' order books fill up it is, of course, just possible they will change their views and return, at any rate in some measure, to the system of forward contracting which has proved so helpful to the iron and steel industries of this area in the past, and a return to which the mills would heartily welcome. On 'Change in Birmingham to-day—Thursday—there was a good attendance. The market tone was bright, as was business in most departments. Orders, however, continue for small tonnages.

Raw Iron.

There is no great activity in the raw iron department. Business has indeed fallen away somewhat since the quarterly meeting a fortnight ago. Smelters are in no wise perturbed, some of them having disposed of their output, at the present rate, for some little time ahead. Having regard to the reports of increasing consumptive demand they look for a renewal of buying in the near future, both on account of the foundries and forges. Particularly in the case of the latter is good business expected to develop, for in the former foundrymen have, in many instances, considerable reserves upon which they are just now drawing, while forgemen have for the most part no stocks of any size to fall back upon. Furnacemen, despite the protests of merchants and consumers, show no sign of wavering as regards pig iron prices. The unanimity in their ranks has proved something of a surprise to many Midland industrialists. At the moment there is no excess of output, and in these circumstances the abstention of merchants and the hand-to-mouth buying of many consumers are not inconsistent with a confident tone among furnacemen who have good order books, and these are fairly numerous. Whether the organisation will be strong enough to hold together under the stress of competition for orders when supply exceeds demand is exercising the minds not only of consumers but of producers also. At date some little dissatisfaction has arisen with certain points in the scheme, the method of quoting delivered prices being regarded in some quarters as troublesome and unnecessary. While there is entire agreement in regard to prices, it is understood that Midland furnacemen are meeting together to consider the points in dispute in the hope of arriving at a thorough understanding.

Steel.

Midland engineers were very pleased with the decision of the Steel Association to leave prices unaltered at £7 17s. 6d. for angles and joists, and £8 12s. 6d. for ship, bridge and tank plates. It came as a welcome surprise, for it was well known that a large number of steelmasters were favourable to an advance, some holding that it was overdue in view of the heavier costs of production, which they state amount to an extra 15s. on every ton of steel as compared with costs when the selling prices were fixed in February of last year. The maintenance of the recent constructional steel values should act as an incentive to the putting into hand of innumerable works which have been "hanging fire." Constructional engineers in this area complain of a shortage of large scale work and of keen competition for all works open to tender. Most descriptions of steel continue in active demand, and there is evidence that native steelworks are maintaining their hold on a bigger proportion of the business available. There is strong pressure for special steels for pressings and other branches of motor car construction. Values of half products continue to mount, and on 'Change in Birmingham this week small bars were quoted at £8 5s. to £8 15s., and mild steel billets £6 10s. The re-appearance of continental steel bars on this market at £7 5s. per ton has done nothing to impair the position of native mills. Foreign billets were offered at £6 1s. to £6 3s. 6d., according to size. Merchants handling continental steel are still able to dispose of fair quantities of steel strip at £7 10s., a figure 20s. below that quoted by local makers.

Staffordshire Bar Iron.

The Staffordshire finished iron trade remains bright, with mills slowly consolidating their position. Makers of marked bars report a constant call for this class of material for specialised engineering requirements. Engineers commend the action of ironmasters in deciding to shoulder the additional costs of production and maintain the price at £12 per ton, a figure which has stood for over twelve months. Their action should further encourage business. In the Crown bar department the effort to raise selling values is maintained. The very low prices quoted till recently are no longer named. The minimum at date appears to be about £9 12s. 6d. Staffordshire makers, it would seem, are eager to get the price on an equality with that which prevails in Lancashire, £10 10s., but buyers hesitate to go much above £10. The market for nut and bolt and fencing bars shows no recovery, and little, if any, interest is displayed in makers' quotations. There is a certain amount of business in Belgian No. 3 iron bars, which are somewhat cheaper at £7 1s. to £7 2s. 6d. per ton delivered into the Black Country.

Galvanised Sheets.

There has been no change of note on the week in the galvanised sheet market. Demand, though slightly brighter than a fortnight ago, remains much below normal, there being a special dearth of orders, both from home and overseas consumers, for 24-gauge corrugated sheets, quotations for which vary from £13 7s. to £13 10s. Lighter gauges are in better demand, as are black sheets for the motor car industry. Midland mills would welcome the revival in buying which they anticipated would have made itself evident before this.

Scrap.

Steel scrap remains very scarce, and prices are high and firm. It is reported this week that the Continent is competing for such supplies as are available. Birmingham merchants have no difficulty in disposing of all they can get to South Wales at £4 per ton.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Decline in Textile Machinery Exports.

FROM the point of view of the Lancashire manufacturer of textile machinery the Board of Trade returns for last month do not make pleasant reading, for the shipments of textile plant during March show a serious falling off compared with either January or February, or with the corresponding period of last year. During the month under review the exports of this class of engineering products reached a total of only £843,072, against £1,080,460 in March, 1928, and £963,098 in the corresponding month of 1927. Relatively, the decline was spread fairly evenly over all classes. Exports of spinning and twisting machinery were of an aggregate value of £652,098, compared with £814,318 in March of last year, and of weaving machinery £125,715, against £194,156. There were increased shipments to China; British India, Australia, and "other European countries," but the takings of all other markets during the month compared with a year ago showed more or less serious declines, exports to Russia, for example, being less by nearly £140,000, and to Germany by over £50,000. British India continues to be the chief individual market, exports thence being valued at £224,944. France was second, with shipments valued at £66,005, followed by Germany, £55,367; China, £53,857; Japan, £47,904; the United States, £45,159; the Netherlands, £41,007; South America, £35,297; Australia, £12,990; and Russia, £3090; "other European countries" taking altogether exports of a total value of £185,932.

Improvement Halted.

Up to the end of February the foreign trade outlook for textile machinery was not unpromising, for exports during the first two months of the year represented an improvement over the already high figures of the January–February period of last year. The March returns, however, have been sufficiently poor to turn what looked like being a surplus compared with the first quarter of 1928 into a very substantial deficit. The exports of textile plant in the three months were valued at £2,849,240, against £3,055,717 last year; spinning and twisting machinery being valued at £2,151,729, compared with £2,298,814, and weaving machinery at £457,141, against £547,495. There was an increase of £50,000 in shipments to British India, over £130,000 to China, and smaller increases to France, Japan, and Australia. There were, however, declines of £142,000 in exports to Russia; £108,000 to Germany, £62,000 to the Netherlands, and nearly £100,000 to "other European countries."

Hopes from Russian Market.

There is no doubt that Lancashire textile engineers are looking to Russia for substantial orders. Mr. J. S. Nuttall, chairman of Platt Brothers, Ltd., textile machinery makers, of Oldham, who was a member of the recent British trade delegation to Russia, says the country is still in need of large quantities of machinery, and that the Soviet scheme for the next five years includes the purchase of £10,000,000 worth of cotton, woollen and flax machinery. He himself came back from Russia with an order for plant to the value of £300,000, which, however, had been the subject of negotiations for some time. In the aggregate, Platt Brothers' contracts for the Russian market during the last few years have reached about £2,000,000. Mr. W. Davidson, chairman of directors, Mr. W. Tweedale, manager, and Mr. S. O. Verity, a director, all of Tweedales and Smalley (1920), Ltd., textile machinery manufacturers, of Rochdale, left this country last week for Russia at the special invitation of the Russian Government, and were expected to be away about a month.

Locomotive Builders' Increased Profits.

Beyer, Peacock and Co., Ltd., locomotive builders of Gorton, Manchester, who, by the way, have just secured important contracts for locomotives for India and Tasmania, report a further improvement in profits on the year's working to the end of December last. After allowing for depreciation, debenture interest and other charges, the net profit for 1928 is shown in the balance-sheet to amount to £39,497, compared with £34,797 in 1927 and £11,197 in 1926. In 1922 the ordinary shareholders received a dividend of 5 per cent., but there was no further distribution on the ordinary shares until 1927, when a dividend of 2½ per cent. was declared. For the past year the directors propose to pay a dividend to the ordinary shareholders of 5 per cent., placing to reserve the sum of £12,000, against nothing in either of the two previous years, and carrying forward £8261.

Wigan Collieries to Merge.

The announcement has been made during the past few days that arrangements have been practically completed for the amalgamation of the Garswood Hall Collieries, Ltd., and the Garswood Coal and Iron Company, Ltd., both of Ashton-in-Makerfield, near Wigan. It is expected that the combined companies will employ about 4000 workpeople, and that the output will be between 5000 tons and 5500 tons a day. This follows upon the more important amalgamation of coal mining companies in the Manchester district and the recent merger of collieries at St. Helens.

Non-ferrous Metals.

The non-ferrous metals markets during the past week may be said to have been in a more normal condition than at any time since the hectic period of the last month or so. Trading, in consequence, has been freer from the disturbing fluctuations that have recently been witnessed, and the speculative element has been less in evidence. For the time being many of the "bulls" will probably be content to rest awhile, and, in a figurative sense, lick their wounds. For the most part operations in the copper section have been on quietly steady lines, and on balance standard brands are about £2 10s. a ton higher than they were a week ago, or roughly £3 10s. a ton in advance of quotations current at the beginning of the year, but nearly £20 a ton below the level of a month ago. At one time during the past week, though not for long, tin fell to a fraction below £200 a ton, the lowest point touched for five or six years. There has been a recovery since to £2 to £3 above this figure, although values on balance for the week have lost ground to the extent of more than £3 a ton. It is interesting to reflect that it is not very long since attempts were being made to "talk" the metal up to £300 a ton, a point which it was within an ace of touching. Only a quiet demand has been experienced, though the low prices have brought out some additional buying. Lead has more than recovered the loss of a week ago, but trade inquiry in this section of the market has been less active. A moderate business has been done in spelter, values of which at the moment of writing are on much the same levels as they were a week ago.

Iron and Steel.

Conditions in the iron and steel markets here have been quiet this week, and, so far as steel is concerned, there appears to be little immediate prospect of expansion. Sellers of foundry iron, however, are hopeful of new forward buying taking place on a bigger scale before long, and, in the meantime, are receiving delivery specifications from local users for fair quantities. There is not the slightest sign of prices easing off. Staffordshire No. 3 is quoted at 73s. 6d. per ton, and Derbyshire at 71s. for delivery to buyers in the Manchester zone. Middlesbrough makes are very firm at about 81s. 6d., and Scottish at 90s. per ton, both delivered in this area. With regard to hematite, the demand locally is about up to its recent average, and prices keep steady at from 86s. 6d. to 87s. per ton, delivered Manchester. There is no more than a quiet demand about for manufactured iron, offers of which are maintained at £10 10s. per ton for Lancashire Crown quality bars and £10 for seconds. Business on the steel market shows a disappointing absence of any indication of improvement, due primarily to the fact that there are few firms of constructional engineers in the district who could not very well do with more work. Buying from other directions at the moment is at the best of moderate extent. Section materials are quoted at £7 17s. 6d. per ton, general plates at £8 12s. 6d.; boiler plates at from £9 12s. 6d. to £9 17s. 6d., according to quality; small re-rolled bars at about £8 10s.; and large bars at £8 17s. 6d. There are comparatively few orders reported either from continental finished steel or for "semis," although the latter are scarce and continue to display firmness, up to £6 5s. per ton being asked here for foreign billets, including delivery to Lancashire buyers. At prices in that neighbourhood, however, there is increasing reluctance to purchase, even when supplies are available.

BARROW-IN-FURNESS.

Hematite.

The hematite pig iron trade on the West Coast continues to be steady, and makers are finding sufficient customers practically to cover the output and at the same time gradually to reduce the stocks which accumulated some months ago. The bulk of trade is such that it does not encourage one to expect an immediate increase in the present number of furnaces in blast in the district, which is eleven. The price at present is making buyers none too eager to place full orders for forward delivery, but, unless there is an easing off in the demand, there is no likelihood of the price being brought down unless under pressure of competition from other districts. It was this competition a few months ago which had the effect of keeping down the price of hematite pig iron. When that ceased, makers in this part of the country were able to get a price which allowed of a small margin. Special qualities are in fair demand, and the continental trade continues steady. There will be more deliveries to America as the contracts are not completed yet. Further business may come along. The local iron trade continues to be steady, but is not at its full production. Foreign ore is being imported in steady tonnage from Spain, Algeria and Norway. The steel trade continues to be moderate, but local makers are still fairly well employed on railway material. Fresh orders would be welcome. The hoop mills are fully employed, mostly on overseas account.

SHEFFIELD.

(From our own Correspondent.)

An Unsatisfactory Opening.

THE second quarter of the year has not, so far, given a very satisfactory account of itself in many of the branches of the steel industry carried on in Sheffield and district. While the heavy commercial steel side is doing well as far as basic material is concerned, the acid branch, which has been poorly employed for a considerable time, gets worse rather than better. Ordinarily, a large proportion of the acid steel produced goes into the manufacture of railway material, but the call from this quarter is at present very low. The axle, tire, and spring departments have probably never had less employment. The home railway companies are still pursuing a policy of the strictest economy, and the call from the colliery companies for wagons is also on a very restricted scale. As regards every-day lines of goods in the manufactured steel departments, the position is unsatisfactory, some leading firms reporting a decline in both orders and inquiries.

Good Lines and Good Prospects.

There is a better report to give when one comes to deal with certain special lines. The automobile industry is one of Sheffield's largest customers for steel in a variety of forms, and its requirements are responsible for a considerable measure of activity on the part of a number of firms. The recently developed trade in hollow forged and hollow rolled drums continues very brisk. There is also a large call for special forgings and castings, cold worked material, and stainless steels. There is keen competition for orders for steel, and although producers are having to pay more for their materials and fuel, much of the work is only secured by keen price-cutting. The increases in price are specially noticeable in the case of the chief ferro-alloys used by steel makers. Tungsten, which is a principal ingredient in high-speed steel, is dearer than it has been for years, quotations having nearly doubled in the past three months. There is a fair amount of confidence in the future. This feeling was expressed a few days ago by Mr. Ronald W. Matthews, President of the Sheffield Chamber of Commerce, who said that trade was undoubtedly improving very slowly. At present it was under the shadow of the impending General Election, but he thought that the signs pointed to the improvement being of a more permanent nature than the various spurts which had been experienced during the last few years.

Future of Low Moor Ironworks.

Good news is to hand with regard to the future of the Low Moor Ironworks, near Bradford, which were recently acquired by Thos. W. Ward, Ltd., Sheffield. The establishment is to continue working to a large extent, and a reconstruction is now taking place. Messrs. Ward have made arrangements with another company to work the forge and rolling mills, so as to continue the manufacture of the well-known Low Moor, Farnley and other best Yorkshire wrought irons. Other interests have taken over the blast-furnaces, coke ovens, and by-products plant, where the production of cold blast pig iron will be continued.

Electric Furnace for Spain.

In a few weeks there will be sent from Sheffield to Reinosa, in Northern Spain, a 30-ton electric furnace, which is the largest of its type constructed in England. It is at present being made by Davy Brothers, Ltd., of Sheffield, at the instructions of Watsons (Metallurgists), Ltd., of Sheffield, and to the Greaves-Etchells patent. The furnace, which has a capacity of 4000 kilowatts, is 16ft. in diameter and uses four 12in. graphite electrodes. An important feature is that it is supplied with mechanical chargers. It will be used in Spain for the production of high-class steels. All the electrical gear—which has been made in other parts of the country—has already been shipped to Spain.

A Remarkable Recovery.

One of the most striking instances of commercial recovery in the annals of Sheffield is furnished by the firm of Darwins, Ltd., manufacturers of various classes of special steel and pioneers in the mass production of safety razor blades in this country. In June, 1927, want of working capital led to the firm going into liquidation, but it has now emerged successfully from that state. Since the liquidator took charge there has been a total profit of £84,719. All creditors are to be paid in full, with 5 per cent. interest, and there is a probability that the number of workpeople—already about 1200—will be increased with the expansion that is likely to come about as the result of a scheme which has been prepared.

Cutlery and Plate.

There is nothing new to report about the condition of the cutlery and plate trades, which is, on the whole, far from satisfactory. The exports of cutlery are well maintained, the figures for the first quarter of the year showing an improvement of £2000, as compared with 1928, and no less than £44,000 as compared with 1926. There was some decline in the overseas demand for knives, but increases in safety blades, scissors, and shears. Imports of cutlery in March were less than in February, but the total for the three months, £190,580, was £61,000 more than in 1928 and £92,000 more than in 1927. With regard to these and the other lighter trades of Sheffield, the President of the Chamber of Commerce has recently made an interesting suggestion of the "rationalisation" order. It seemed to him, he said, that a solution of the difficulties in many of the lighter trades might be found in some system providing for co-operative manufacture on a horizontal basis and co-operative selling on a vertical basis. Where they had a large number of firms manufacturing similar products it might be possible to reduce overhead charges by pooling resources. He suggested that it might be possible for the Chamber of Commerce to act as a sort of clearing house, enabling any firms that liked to investigate any line of co-operation in production or salesmanship.

Government Orders.

Sheffield and district firms will benefit by a large number of orders which have been given out recently by various Government departments. Among the firms concerned are the following:—Chesterfield Tube Company, oxygen cylinders, and Thos. Firth and Sons, Ltd., cast steel condenser doors, for the Admiralty; Parkgate Iron and Steel Company, plates and rivets, for the same Department; Vickers-Armstrongs, steel forgings, for the War Office; Howell and Co., boiler tubes; Staveley Coal and Iron Company, pipes; Edgar Allen and Co., stone crushers; Newton, Chambers and Co., tanks, all for the Crown Agents for the Colonies; T. W. Ward, Ltd., steelwork, for H.M. Office of Works; S. Osborn and Co., T. Firth and Co., and Cammell Laird and Co., tool steel, for the Admiralty; and a number of firms, cutlery for the Admiralty.

Lincolnshire Sea Defences.

The Spilsby Court of Sewers is to proceed with its scheme for combating erosion in connection with the Ingoldmells sea defences, which is estimated to cost nearly £5000. The Ministry concerned has agreed that the work shall go on, and the Grants Committee will give assistance, amounting altogether to 55 per cent. of the cost, on condition that the work is taken in hand at once and is completed within eight months of the commencement.

Hull Electrical Progress.

The latest report with regard to the municipal electricity undertaking of the Hull Corporation is interesting, and shows that the department continues to make progress. In one year the units generated have increased from 84 to 90 millions, while during the past quarter there were 1739 applications for lighting and power and 700 for wiring. The Electricity Committee has decided to apply for new loan sanctions amounting to £100,000 for maintenance and service, and £50,000 for new sub-stations.

West Riding Colliery Sold.

The Shuttle Eye Colliery at Grange Moor, Wakefield, was sold by auction last week for £36,500. It was disposed of as a going concern. It has two shafts, with a normal output of 150 tons a day. It produces coal which is suitable for gas, steam and coking purposes, for which there is a good demand locally.

NORTH OF ENGLAND.

(From our own Correspondent.)

More Shipbuilding Orders.

THE upward trend of the shipbuilding industry on the North-East Coast still continues, orders for three more vessels having been placed during the past few days. There has been quite a lull during the past six or seven weeks, but a number of inquiries are again circulating for new tonnage and more orders are expected in the near future. The most important order received this week is that by Sir W. G. Armstrong, Whitworth and Co., Ltd., for the construction of an oil tank vessel of 8800 tons deadweight for Mr. Pergjerding, of Bergen. This vessel will be a sister ship to the "Binta," constructed by the firm for the same owner in 1928. Swan, Hunter and Wigham Richardson, Ltd., have booked an order for a vessel of moderate size for the Maltese Government, which will be built at their Neptune Yard, while Craig, Taylor and Co., Ltd., Stockton-on-Tees, have secured an order for an 8400-ton vessel for British owners. The engines will be constructed by Blair and Co.,Ltd., Stockton-on-Tees.

Cleveland Iron Trade.

Inquiries for Cleveland pig iron from a wide area are very numerous, and a considerable tonnage could be disposed of were it available. At the moment there is virtually a famine in Cleveland iron, and the forthcoming enlargement of production will not nearly satisfy needs, as the volume of trade is heavy and increasing. A hematite furnace is being blown in at the Newport Works of Dorman, Long and Co., Ltd., Middlesbrough, and the Palmer Shipbuilding and Iron Company, Ltd., is starting two furnaces at Jarrow—one on Cleveland pig iron and the other on hematite—early next month. The number of furnaces in operation on the North-East Coast will thus be increased to thirty-nine. This is still less than half the number erected, but much of the plant standing is obsolete, and will not again be put into operation, while works running are turning out vastly more pig iron per furnace than in pre-war days. Prices are very firm, No. 1 Cleveland foundry iron being 71s.; No. 3 G.M.B., 68s. 6d.; No. 4 foundry, 67s. 6d.; and No. 4 forge, 67s. It is noteworthy as showing the expansion in trade that with a week still to go the April shipments of pig iron from the river Tees exceed those of March, which were the highest recorded for three years.

Ironmaking Materials.

Though sales are on a very limited scale, foreign ore quotations are strong. Merchants have good contracts arranged, and do not need to seek new business. Prices are based on fully 23s. c.i.f. Tees for best Rubio. Values of blast-furnace coke are easing as scarcity becomes less acute, but values are still on too high a level to meet the views of local consumers. There are sellers of good medium qualities at 19s. delivered to works in this district.

Hematite Pig Iron.

Shipments of East Coast hematite pig iron, spiegel, and ferro-manganese this month have been on an exceptionally big scale, and the April exports promise to be the heaviest recorded since the coal strike of 1921. With cheaper fuel, hematite manufacture is now on a profitable basis. Recognised market values are unaltered, but the tendency is upward. For delivery over periods in the third quarter of the year contracts are being arranged at 74s. for mixed numbers, and substantially above that figure has been realised for iron of special quality made to stipulated analysis.

Manufactured Iron and Steel.

Very active conditions prevail in the manufactured iron and steel trade, contracts on hand assuring the works of brisk employment well into the autumn. There is very little foreign steel now on offer, and prices are so much higher that British producers have the field largely to themselves. Semi-finished products are in good demand, and plant in the various branches is running at high pressure. There is rather more export trade in finished steel, and among inquiries circulating are some from the Far East and from India. Quotations of all descriptions of finished material having been left unchanged, a period of continued activity is anticipated.

Big Order for Steel Rails.

Dorman, Long and Co., Ltd., the Tees-side steel firm, has received an order from the Union of South Africa for between 30,000 tons and 40,000 tons of steel rails. The securing of this order is an interesting sequel to the South African scandal of some months ago, when many tons of steel rails of foreign manufacture had to be scrapped. The fact that the Union has now decided to place such a big order with British firms is extremely satisfactory to British steelmakers. The order, which also includes 1000 tons of steel fish-plates, will be spread over the next four months.

The Coal Trade.

The Northern coal trade position continues very satisfactory, and the exceedingly steady tone all round is no doubt something of a surprise to those who a month ago thought the market would ease as May approached. No weakening is discernible, and the collieries are hopeful of a continuance of good trade. Output is heavily sold, and any odd lots offered for early shipment are taken up at sellers' prices. The demand is now so widespread that foreign competition, while not underrated, is not felt so acutely as it was last year. Moreover, there are wages and hours questions pending in Poland and in the Ruhr, and any concessions to the miners will be reflected in higher prices for foreign coals. Business is coming forward in the Northern market in such volume as to justify the belief that industries at home and abroad are expanding in a very encouraging way—not spasmodically, but in a gradual and lasting manner. Coking coal, for example, is meeting with a widespread trade, and up to 16s. has been paid for good average kinds for delivery in May. This is indicative of the sustained strength of this section. Northumberland steam coals are holding firmly to late prices, and there have been direct sales over the second half of the year at little less than the prevailing figures. In Durham County there is a heavy demand for steams of all qualities, and gas coals are likewise maintaining a very healthy tone. Fitters are in no section making any concessions. Easing of prices of blast-furnace coke is very acceptable to the several additional furnaces about to be rekindled, and output will find a ready sale for some time to come, even though the export trade be dull at the moment. The demand for other descriptions is quiet, and, with stocks steadily increasing, makers are eager to get additional tonnage stemmed, but stand against making any further concessions in prices. Second-hand holders offer freely at slight discounts. Gas coke is quoted at 18s. 6d. to 19s.; beehive and special foundry, 25s. to 28s. 6d.; patent oven cokes, 18s. to 19s.

SCOTLAND.

(From our own Correspondent.)

Signs of Improvement.

REPORTS to hand concerning certain departments of the steel and iron industries appear to indicate brighter times ahead. Though the improvement is not general, production has expanded in several lines, and foreign inquiries are evidently increasing. While there has been a lull in shipbuilding specifications, steelmakers are of the opinion that this is only temporary, being confident that a considerable amount of business has still to be placed on account of shipbuilding orders booked within recent months. Shipbuilding contracts have been slow of late, but there seems good reason to hope that a change will soon be noticeable in this respect. The coal trade is rather depressed meantime, and the outlook none too bright, in view of the advance of the season.

Work in Clyde Shipyards.

At present there are about 120 vessels, of 580,000 tons, being built and fitted out on the Clyde. These figures are about the average for the years between 1922 and 1925, but considerably below pre-war standards.

Steel.

Steelmakers, it is said, are benefiting to some extent by the state of affairs on the Continent. So far as heavy steel is concerned, mills have more orders meantime for sections than plates, but an improvement in the latter is anticipated before long. Steel sheets are somewhat disappointing for this time of the year, especially galvanised descriptions, but here again there are indications of expansion.

Tubes.

Tube makers continue busy in practically all departments. A feature at present is the demand for boiler tubes.

Iron.

Bar iron makers are not particularly busy in the iron departments, but have a fair measure of activity in the re-rolled steel department, where there has been a decided expansion in demands for tube strips. Re-rollers, however, still experience some difficulty from scarce and dear supplies of foreign semis.

Pig Iron.

Business in pig iron has improved a shade of late. Hematite in particular shows a fair demand, and foundries are taking more deliveries than for some considerable time. Minimum prices are unchanged from last week.

Exports and Imports.

During the past week some 12,000 tons of iron ore, 1800 tons of iron and steel, and 3300 tons of pig iron were discharged at Glasgow Harbour. Exports included 2700 tons of steel and iron and 463 tons of pig iron.

Further Reduction in Manufactured Copper.

A further reduction has been announced in manufactured copper, making the price for strong £112 per ton basis.

Shale Workers' Wages.

On April 17th wages of workmen employed in and about shale mines and works were increased by 5 per cent. on wages ruling on October 18th, 1927. This means an increase on all tonnage rates of 5 per cent., and a similar increase on all shift rates, thus restoring the wages to the level pertaining immediately prior to the reduction made on January 18th, 1928. Recently there has been an increase in the value of shale products, and the directors of Scottish Oils, Ltd., desire the workers to benefit thereby. Progress is being made with the erection of plant for the improved method of refining.

Coal.

There is no sign of a recovery in the coal trade, and depression is general in all districts. Fuel for shipment is more freely offered, owing to declining home demands and increased outputs. Many colliery sidings are becoming congested with loaded wagons, and for prompt orders price concessions are, as a rule, obtainable. Forward business is extremely meagre, as foreign buyers are not disposed to pay the prices asked, and exporters are not prepared to discount colliery quotations, in view of the possible effect on the market of the outcome of negotiations on foot for a new scheme to stabilise the industry. Aggregate shipments amounted to 229,117 tons, against 228,119 tons in the preceding week, and 216,728 tons in the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

ALTHOUGH the conditions in the steam coal trade are not what they were a few weeks ago, and general business is quieter, the fact remains that the tendency of values to ease off is a slower process than many buyers probably expected. In other words, the market is keeping up very well, all things considered, and the probability is that prices will not for some weeks, at any rate, come back to the level that was thought likely in some quarters. Most of the leading collieries are in a stronger position for this month and next than was realised, though there is this to be said that much depends upon their contractors taking out the coals that they have arranged for. If these contractors find it difficult to secure new orders there will not, of course, be the ready outlet for the coals, and the collieries will be in the position of being well sold on paper and yet not be able to effect shipment. Tonnage must be put at their disposal, and unfortunately it is the question of tonnage supplies which is such an important factor. Chartering has again shown a tendency to fall off rather than improve, this being attributable partly to the decline in the current demand from consumers abroad and the fact that while a fair number of orders are in hand, merchants are experiencing some difficulty in securing the right tonnage that they require. Foreign coal exports last week certainly displayed an advance upon the figures of the preceding week and came to 502,564 tons, as against 479,270 tons, but an improvement even upon this total is necessary to infuse real strength into the market. At the end of last week there were thirteen tipping appliances idle at the various docks, while the number of waiting vessels was ten, though during the week the tonnage position was less favourable. Tonnage arrivals since then have not been very satisfactory, as this week was started with nineteen tips idle and only sixteen steamers waiting to berth. So far as contract business in coals is concerned, there is no news at the time of writing of the actual placing of the contract for the supply of 180,000 metric tons of locomotive coals to the Egyptian State Railways, particulars of which were referred to last week, while tenders have gone in this week for about 200,000 tons of best large coals for the Central Railways of Brazil to be delivered at Rio de Janeiro during the next four months. The Spanish Naval Commission purchased at the end of last week 6000 tons of superior Admiralty large coals for early delivery, while news has now been received that the Norte Railways of Spain are in the market for 30,000 tons of large coals for delivery during the next three months at various Spanish ports.

Developments at Bedwas.

On Monday a party visited the Bedwas Colliery at the invitation of the directors of British Benzol and Coal Distillation, Ltd., to inspect the coal distillation plant which is in process of installation by the Woodall-Duckham company. This plant is now nearing completion, and is designed to coke nearly 700 tons of coal per day, while it is expected that in the course of the next few months the production of about one and a-half million gallons of motor spirit and other oils per annum will be achieved. During the party's tour of the colliery, the Parsons' turbo air compressor, capable of compressing 24,000 cubic feet of free air per minute, was started for the first time. This new compressor is of 4730 horse-power, and the set is fitted with a Le Blanc jet condenser.

S. W. M. F. Affairs.

The special Conference of the South Wales Miners' Federation, which met at Cardiff on Thursday last week chiefly for the purpose of considering the question of the re-organisation of the Federation unexpectedly rejected the elaborate scheme which had been drafted. A direct amendment by seven lodges to reject the proposals was carried, and it was then explained that the position now was that the present constitution of the Federation was to remain subject to amendments of the rules at a further Conference.

Steel and Tin-plate Trades.

The quarterly ascertainment under the sliding scale in operation in the steel works in West Wales, which has been received at Swansea, shows that the average price of bars for the three months ended March 31st was equivalent to 7½ per cent. on the base rate of pay under the sliding scale. This means an increase of 1¼ per cent. over the previous ascertainment, and will govern the wages payable during the three months commencing May 5th. Certain *ex-gratia* payments are being made to the lower-paid men at present, and, as is usual, the continuation of these bonuses will be a matter for negotiation between the parties concerned at a meeting to be held shortly. A number of important matters are to come up for discussion at the next meeting of the Joint Industrial Council in the tin-plate trade, among them being the rates for new machinery at the Elba Works, Swansea, and the Burry Works, Llanelly. The Elba Works have withdrawn from the membership of the Joint Industrial Council. It is also understood that the question is to be raised of the policy of erecting mills at a time when the demand for tin-plates is no more than 75 per cent. of the capacity of the existing works.

Current Business.

The steam coal trade displays a certain amount of irregularity, but for the most part prices are very steady for the leading qualities for loading this month and the early part of May. On the whole, prices are a shade lower than they were recently, but collieries are declining to make any concession upon 21s. for superior Admiralty large coals and 14s. for best smalls for prompt shipment, though for business forward there is a disposition to meet buyers on a reasonable basis. Inasmuch as the outlook is somewhat uncertain, buyers are cautious about operating ahead. Coke is firm and moves off freely, and patent fuel is about steady, but pitwood is quiet at round about 27s. to 27s. 3d.

Contracts.

THORNYCROFT AND CO., Ltd., have recently received orders for over a hundred rigid six-wheeled type motor vehicles from railway companies, governments, municipal and commercial firms at home, the Argentine, Brazil, Africa, New Zealand, Roumania, &c.

THE "DE MAAS" SHIPBUILDING COMPANY, of Slikkerveer, Holland, has received orders to build three Diesel ships, 165ft. by 28ft. 8in. by 10ft.—400 tons deadweight, each to be fitted with a 250 H.P. "Sulzer" motor installation to give a speed of 8½ knots loaded.

ROYCE, Ltd., of Trafford Park, Manchester, have recently received orders for :—(*a*) Five electric overhead cranes from Davey, Paxman and Co., Ltd. ; (*b*) three electric cranes for a railway company in Brazil ; (*c*) an overhead crane for Buenos Aires ; (*d*) an overhead crane for South Africa ; (*e*) two cranes for the British Isles ; and (*f*) an electric capstan for India.

SIR W. G. ARMSTRONG, WHITWORTH AND CO., Ltd., have received an order to construct an oil tank vessel of 8800 tons deadweight for Mr. Per Gjerding, of Bergen. The propelling machinery will consist of Armstrong-Sulzer Diesel engines, which will be constructed by the builders. This vessel will be the one hundred and sixty-second oil tanker to be built by Armstrong, Whitworth.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has received from the Société Belge Radioelectrique, on behalf of the Belgian Government, an order for a short-wave telegraph-telephone transmitter which will be used for communication between Belgium and the Belgian Congo and Belgium and South America, and for two short-wave receivers of the latest type, similar to those used in the Marconi Beam stations.

THE WERKSPOOR ENGINE WORKS at Amsterdam have received the order for the propelling machinery of the twin-screw motor vessel "Colombia," which is being built by the P. Smit Jr. Company of Rotterdam, for the Royal Netherlands Steamship Company. The engines will comprise two single-acting, eight-cylinder, four-stroke motors, with cylinders 780 mm. by 1400 mm. fitted with the firm's new supercharging system.

BIRMINGHAM ELECTRIC FURNACES, Ltd., has recently received the following orders :—(*a*) For an electric re-heating furnace, from Moss Gears Co., Ltd., of Tyburn, Birmingham ; (*b*) for a box type electric furnace for carburising for the Alvis Car and Engineering Company, Limited, of Coventry ; (*c*) for an electric re-heating furnace for the same firm ; and (*d*) for three electric re-heating furnaces, David Brown and Sons, Ltd., of Huddersfield.

VICKERS-ARMSTRONGS, Ltd., Elswick Works, Newcastle-on-Tyne, has been entrusted by Lever Brothers, Ltd., with the order for the hydraulic equipment for the entrance lock of the new dock at Bromborough. The lock gates for the dock are now in course of manufacture by Vickers-Armstrongs at Barrow. The same firm has recently received orders for six hydraulic capstans for the Calcutta Port Commissioners, and for two electrical capstans for the East Indian Railway.

BRITISH BROWN-BOVERI, Ltd., has received from the New South Wales Government an order for high-power rectifiers for railway work, similar to those supplied in May of last year. The order comprises three equipments, each for an output of 1500 kW at 1500 volts direct-current, two being for an extension of the Granville sub-station, and the third for the extension of the Cabramatta—formerly Cabravale—sub-station. All three equipments are to be arranged for complete automatic control.

RUTHS STEAM STORAGE, Ltd., of Africa House, Kingsway, London, W.C. 2, has received an order for a steam storage plant from the Gas Light and Coke Company for the latter's new works at Brentford. The overall length of the accumulator shell will be 55ft. 6in. and the diameter 13ft. 10½in., and it will be designed to operate between pressures of 160 lb. and 100 lb. per square inch. The same firm has also received an order for an accumulator plant from Francis Stevenson and Sons, Ltd., for the Lawside Dye Works, Dundee.

GREAT WESTERN RAILWAY officially announces the following contracts have been placed :—(1) Supply and delivery of a punching and shearing machine for the Carriage Works, Swindon : Henry Pels, 32/38, Osnaburgh-street, London ; (2) supply and delivery of a 10¼in. S.S. and screw-cutting lathe, for the Locomotive Works at Swindon : J. Lang and Sons, Ltd., Johnstone, Glasgow ; (3) supply and delivery of one "Lindnor" thread grinding machine, for the Locomotive Works, at Swindon : Dowdings Machine Tool Company, 38, Albert Embankment, Vauxhall, S.E. ; (4) cleaning and repairing station buildings, &c., at Corsham Box, &c., Staverton Halt, Holt Junction, &c., Bristol West Department, Clifton Bridge, &c. : W. T. Pickering, 38, Parliament-street, Stockton-on-Tees ; (5) cleaning and repairing station buildings at Birmingham (Moor-street) : Decra Ltd., Hanbury-road, Acton, W. 3 ; (6) cleaning and repairing station buildings at Hockley : Norman Goodall, 2, Glendare-road, Lidget Green, Bradford ; (7) cleaning and repairing station buildings at Swan Village, Wednesbury, &c., Great Bridge, Dudley, &c. : Fields, Ltd., 27, Wollaton-street, Nottingham ; (8) cleaning and repairing station buildings at Wolverhampton and Wellington (Salop) : Fones and Sons, The Uplands, Gough-road, Coxley, near Bilston ; (9) cleaning and repairing station buildings at Penryn, Falmouth and Perranporth : Alfred Bagnall and Sons, Ltd., Shipley, Yorks ; (10) supply and delivery of six "R" type 25 cwt. chassis : Morris Commercial Cars, Ltd., Foundry-lane Works, Soho, Birmingham ; (11) supply and delivery of six 14-seater omnibus bodies : John Buckingham, Ltd., 332 and 333, Bradford-street, Birmingham ; (12) supply and delivery of eleven "Luxury" coach bodies for six-cylinder Thornycroft chassis : Vickers (Crayford), Ltd., Crayford Works, Crayford, Kent ; (13) supply and delivery of model P.H. elevating platform truck for Barry Docks : R. A. Lister and Co., Ltd., Dursley, Gloucester ; (14) repairs for the overhaul of ss. "Great Southern" : Chas. Hill and Son, Ltd., Albion Dockyard, Cumberland-road, Bristol ; (15) repairs for the overhaul of ss. "St. Julien" : J. Gordon, Alison and Co., Ltd., Dock Engine Works, Birkenhead ; (16) repairs for the overhaul of No. 1 grab crane at Barry : Hodges and Co., Ltd., Barry Dock ; (17) repairs for the overhaul of steam hopper barge "No. 4" : Ocean Dry Docks Co., Ltd., Central and Albion Dry Docks, Swansea ; (18) repairs for the overhaul of ss. "Sambur" : Cardiff Channel Dry Docks and Co., Cardiff ; (19) supply and erection of a refreshment kiosk at Cardiff Station : Wm. T. Nicholls, Ltd., St. Pauls-road, Gloucester ; (20) construction of ladies' accommodation under No. 1 platform, Paddington Station ; (21) external painting and repairs required at Great Western Hotel, Taunton : Stansell and Son, East-street and Billett-street, Taunton ; (22) erection of a block of business and residential premises near West Acton Station : R. Mansell, 17-23, Grant-road, Croydon ; (23) alterations, cleaning and repainting at 23, Newgate-street, E.C. : Edward Proctor and Sons, Ltd., 326, High-street, Plumstead, S.E. ; (24) supply of steel girders and other steel and ironwork : Horsehay Company, Ltd., Horsehay, Wellington, Salop ; (25) supply and erection of refuse destructor plant at Old Saw Mill and West End Saw Mill, Carriage Works, Swindon : New Destructor Company, Ltd., Atlas Works, Pershore, Worcester ; (26) steel lattice girders, stanchions, &c., for Barry Island Station : Arch. D. Dawnay and Sons, Ltd., Kings Dock, Swansea ; (27) supply and erection of a pair of dock gates and other works for the sea entrance to the Bute West Dock Basin, Cardiff : Fairfield Shipbuilding and Engineering Company, Ltd., Chepstow Works, Chepstow ; (28) supply and erection of electrically-driven service lift at Newport (High-street) Station : Austin and Co., Dunn-street, Newcastle-on-Tyne ; (29) supply and erection of a 10-cwt. freight lift at Newport (High-street) Station : Titan Lift Company, Ltd., 21, Pancras-road, N.W. 1 ; (30) supply and erection of a 15-cwt. passenger lift at Newport (High-street) Station : Titan Lift Company, Ltd., 21, Pancras-road, N.W. 1 ; (31) repairs for the overhaul of the steam hopper barge "Foremost VI." : Port Talbot Graving Docks Company, Ltd., Port Talbot ; (32) supply and delivery of two Morris trucks : Morris Commercial Cars, Ltd., Soho, Birmingham ; and (33) construction of a retaining wall near Old Oak Common Halt, W. : Holliday and Greenwood, Ltd., 11, Buckingham Palace Gardens, London, S.W. 1.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

C. A. BALDWIN AND CO. ask us to announce that they have changed their address from 18, St. Thomas'-street, London Bridge, S.E. 1, to 52, Weston-street, London Bridge, S.E. 1. Telegrams, Exsupereet, Boroh, London. Telephone number as before, Hop 0305.

NATIONAL FEDERATION OF IRON AND STEEL MANUFACTURERS.—At the annual general meeting of the National Federation of Iron and Steel Manufacturers, held in London on April 18th, under the presidency of Mr. E. J. FOX, Sir Peter Rylands (chairman of Pearson and Knowles Coal and Iron Company, Ltd., Partington Steel and Iron Company, Ltd., and other iron and steel companies) was elected President for 1930, and the Hon. Roland D. Kitson (chairman of Bolckow, Vaughan and Co., Ltd.), Mr. A. J. Grant (managing director of John Brown and Co., Ltd.), and Mr. E. J. George (of the Consett Iron Company, Ltd.), were elected vice-presidents of the Federation.

ELECTRICAL INSTALLATION WORK.—In 1928 the Electrical Contractors' Association and the City and Guilds of London Institute jointly formed an Advisory Committee on Electrical Installation Work, including representatives both of the industry and of the following educational authorities :—The Board of Education, the Association of Education Committees, the County Councils Association, the Associations of Technical Institutions, of Principals of Technical Institutions, and of Teachers in Technical Institutions. The above Advisory Committee has drafted a new scheme of syllabuses and of certification in electrical installation work, and it has been adopted by the City and Guilds of London Institute for the purpose of its examinations, and by the Electrical Contractors' Association in connection with its apprenticeship scheme. A separate pamphlet has been issued in regard thereto, and copies may be obtained from the Department of Technology, 29, Roland-gardens, London, S.W. 7. The Advisory Committee further desires to recommend to Local Education Authorities that there should also, if possible, be a course of instruction for students from fourteen to sixteen years of age, preparatory to entry to the classes in Technical Colleges and to the examinations of the City and Guilds of London Institute in the technical subject. A "Course for Junior Electricians," designed to cover the critical period of two years between the elementary and the technical school is suggested, and it is the hope of the Advisory Committee that such courses may be set up by Local Education Authorities, and that by such a course the interest of boys may be aroused and their attention directed to electrical matters with a view to their subsequent entry to the electrical industry.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
(1) Native	19/6 to 21/-
(1) Spanish	21/-
(1) N. African	21/-
N.E. COAST—	
Native	18/- to 21/-
Foreign (c.i.f.)	23/-

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 17 0	—
No. 1 Foundry	3 15 0	—
No. 3 Foundry	3 12 6	—
N.E. COAST—		
Hematite Mixed Nos.	3 14 0	3 14 0
No. 1	3 14 6	3 14 6
Cleveland—		
No. 1	3 11 0	3 11 0
Silicious Iron	3 11 0	3 11 0
No. 3 G.M.B.	3 8 6	3 8 6
No. 4 Foundry	3 7 6	3 7 6
No. 4 Forge	3 7 0	3 7 0
Mottled	3 6 6	3 6 6
White	3 6 6	3 6 6
MIDLANDS—		
(3) Staffs.—	(*Delivered to Station*)	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 11 0	—
" " Foundry	3 15 0	—
(3) Northampton—		
Foundry No. 3	3 9 0	—
Forge	3 5 0	—
(1) Derbyshire—		
No. 3 Foundry	3 12 6	—
Forge	3 8 6	—
(3) Lincolnshire—		
No. 3 Foundry	3 6 0	—
No. 4 Forge	3 0 0	—
Basic	—	—
(4) N.W. COAST— N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 4 6 (*a*); 4 7 6 (*b*); 4 11 0 (*c*)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 10 0	—
Common Bars	10 15 0	—
Best Bars	11 5 0	—
Double Best Bars	11 15 0	—
Treble Best Bars	12 5 0	—
LANCS.—		
Crown Bars	10 10 0	—
Second Quality Bars	10 0 0	—
Hoops	13 0 0	—
S. YORKS.—		
Crown Bars	10 10 0	—
Best Bars	11 10 0	—
Hoops	12 10 0	—
MIDLANDS—		
Crown Bars	9 15 0 to 10 0 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 12 6 to 8 17 6	—
Gas Tube Strip	10 17 6	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	10 10 0	10 10 0
Ship Plates, ¼in. and up	8 7 6	7 12 6
Sections	7 17 6	7 2 6
Steel Sheets, ¼in.	8 15 0	8 12 6
Sheets (Gal. Cor. 24 B.G.)	13 10 0	13 12 6 to 13 15 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 15 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 2 6	—
Soft Billets	6 17 6	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 0 0	—
Light Rails	8 5 0 to 8 10 0	—
Billets	6 15 0 to 9 0 0	—
MANCHESTER—		
Bars (Round)	8 17 6	—
" (Small Round)	8 10 0	—
Hoops (Baling)	10 0 0	9 15 0
" (Soft Steel)	9 0 0	8 15 0
Plates	8 12 6 to 8 17 6	—
" (Lancs. Boiler)	9 12 6 to 9 17 6	—
SHEFFIELD—		
Siemens Acid Billets	8 15 0 to 9 0 0	—
Hard Basic	9 2 6 and 9 12 6	—
Intermediate Basic	7 12 6 and 8 2 6	—
Soft Basic	7 0 0	—
Hoops	9 10 0	—
Soft Wire Rods	7 12 6	—
MIDLANDS—		
Small Rolled Bars	8 5 0 to 8 10 0	—
Billets and Sheet Bars	6 7 6 to 6 10 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	—
Galv. Sheets, f.o.b. L'pool	13 7 6 to 13 10 0	—
Angles	7 17 6	—
Joists	7 17 6	—
Tees	8 17 6	—
Bridge and Tank Plates	8 12 6	—
Boiler Plates	9 15 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	18.4½ to 18/9
Block Tin (cash)	202 5 0
" " (three months)	204 5 0
Copper (cash)	77 15 0
" (three months)	74 15 0
Spanish Lead (cash)	24 15 0
" " (three months)	24 3 9
Spelter (cash)	26 11 3
" (three months)	26 8 9
MANCHESTER—	
Copper, Best Selected Ingots	82 10 0
" Electrolytic	84 15 0
" Strong Sheets	112 0 0
" Tubes (Basis Price), lb.	0 1 3½
Brass Tubes (Basis Price), lb.	0 1 1½
" Condenser, lb.	0 1 3½
Lead, English	26 10 0
" Foreign	24 15 0
Spelter	26 10 0
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/2 per lb.	
Ferro Tungsten	2/10 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£25 0 0	7/6
" " 6 p.c. to 8 p.c.	£24 0 0	7/-
" " 8 p.c. to 10 p.c.	£23 10 0	6/-
" " Specially refined		
" " Max. 2 p.c. carbon	£38 0 0	12/-
" " " 1 p.c. carbon	£40 0 0	15/-
" " " 0·70 p.c. carbon	£45 0 0	17/-
" " " carbon free	1/2 per lb.	
Metallic Chromium	2/6 per lb.	
Ferro Manganese (per ton)	£13 15 0 for home; £13 10 0 for export	
" Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/- per unit	
" " 75 p.c.	£19 10 0 scale 6/- per unit	
" Vanadium	13/9 per lb	
" Molybdenum	3/8 per lb.	
" Titanium (carbon free)	1/- per lb.	
Nickel (per ton)	£170 to £175	
Ferro-Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(*Prices not stable.*)

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	13/6
" " Ell	15/-
" " Splint	16/- to 16/6
" " Trebles	13/6
" " Doubles	12/9
" " Singles	11/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	14/6
" " Jewel	17/6
" " Trebles	13/6
FIFESHIRE—	
f.o.b. Methil or Burntisland—Steam	12/- to 13/6
Screened Navigation	17/6
Trebles	13/6 to 14/-
Doubles	12/6
Singles	11/9
LOTHIANS—	
(f.o.b. Leith)—Best Steam	13/-
Secondary Steam	13/-
Trebles	13/6
Doubles	12/6
Singles	11/6

ENGLAND.

	Inland.	Export.
(8) N.W. COAST—		
Steams		25/-
Household		39/6 to 52/-
Coke		23/6 to 24/-
NORTHUMBERLAND—		
Best Steams		16/- to 16/3
Second Steams		15/6
Steam Smalls		10/6 to 11/-
Unscreened		14/- to 14/6
Household		21/- to 27/-
DURHAM—		
Best Gas		15/6
Second		15/- to 15/3
Household		21/- to 27/-
Foundry Coke		22/6 to 25/-
SHEFFIELD—		
Best Hand-picked Branch	27/- to 28/6	—
Derbyshire Best Bright House	20/- to 23/-	—
Best House Coal	19/6 to 20/6	—
Screened House Coal	17/6 to 18/6	—
" " Nuts	16/- to 17/6	—
Yorkshire Hards	15/6 to 16/6	—
Derbyshire Hards	15/6 to 16/6	—
Rough Slacks	8/6 to 9/6	—
Nutty Slacks	6/- to 7/-	—
Smalls	2/6 to 4/-	—
Blast-furnace Coke (Inland)	14/6 at ovens	—
Furnace and Foundry Coke (Export), f.o.b.		20/- to 20/6

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	21/- to 21/3
Second Smokeless Large	20/6 to 20/9
Best Dry Large	20/6 to 21/-
Ordinary Dry Large	19 9 to 20/3
Best Black Vein Large	20/6 to 20/9
Western Valley Large	20/3 to 20/6
Best Eastern Valley Large	19/6 to 20/-
Ordinary Eastern Valley Large	19/- to 19/6
Best Steam Smalls	14/6 to 14/9
Ordinary Smalls	12/6 to 14/-
Washed Nuts	20/- to 24/-
No. 3 Rhondda Large	21/- to 22/-
" " Smalls	15/- to 15/6
No. 2 " Large	18/- to 19/-
" " Through	17/- to 18/-
" " Smalls	13/- to 13/6
Foundry Coke (export)	26/6 to 36/-
Furnace Coke (export)	19/- to 21/-
Patent Fuel	20/6 to 21/6
Pitwood (ex ship)	26/9 to 27/-
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	33/- to 35/-
Seconds	25/- to 29/-
Red Vein	24/- to 27/-
Machine-made Cobbles	40/- to 43/6
Nuts	40/- to 44/-
Beans	23/6 to 25/6
Peas	16/6 to 17/6
Breaker Duff	9/6 to 10/-
Rubbly Culm	9/9 to 10/3
Steam Coals:	
Large	18/- to 19/-
Seconds	17/- to 18/-
Smalls	10/6 to 13/-
Cargo Through	15/9 to 16/9

(1) Delivered. (2) Net Makers' Works. (3) f.o.t. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire. (6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate 12/6 joists and 10/- all other materials if home consumers confine purchases solely to British products.

French Engineering Notes.

(From our Correspondent in Paris.)

The Tube Union.

THE negotiations for extending the continental tube makers' union to include manufacturers in Great Britain, the United States and Canada are well advanced, and it appears likely that the international union will be definitely constituted before long. An understanding has already been come to amongst European and Transatlantic tube firms whereby minimum prices are fixed for gas, water, steam and some other tubes. A quota is provided for each country, and members undertake not to export to other countries belonging to the union. The conditions are much the same as those of the Steel Cartel. There will be penalties for an excess production, as well as for any infringement of the regulations. A contribution of 1s. per ton of tubes exported will be made to a reserve fund.

Labour.

The labour trouble lies not so much in the number of men available as in their quality, and it is becoming increasingly difficult to find skilled hands, so that in some industries it is almost impossible to secure a maximum output. This is especially the case with ironfounders, who are a long way behind with deliveries, and the failure of supplies is necessarily causing trouble in other branches of industry. Even the State Labour Bureau, which is working more for the benefit of employers than of the men, complains that the offers of employment are far in excess of the demands. One of the leading motor car firms posted notices in agricultural districts pointing out to workers the advantages of accepting jobs in industrial centres. This is quite at variance with the national policy of keeping labour on the land, but it shows the extent to which big employers are pushed in order to obtain labour. Meanwhile, immigration of foreign labour continues to be encouraged, the great majority of those coming into the country being Poles, Belgians and Spaniards, but this does not solve the problem of supplying skilled hands.

Naval Aviation.

The failure of the Air Minister to secure control over all branches of the air service has been followed by a strengthening of the autonomy of the military and naval departments, which, while dependent upon the Air Ministry for the supply of machines, are taking their own initiative in all matters affecting the character of the machines required and the manner in which they are to be used. The technical work, however, is still centralised in the Air Ministry, and that lessens, somewhat, the force of the criticisms that are levelled against the separation of the services on the ground that an absence of unity is detrimental to the development of aviation. As a matter of fact, the naval department is endeavouring to make up for lost time, since, until two or three years ago, seaplane construction was quite neglected, and the work now being done promises, before long, to provide the fleet with an ample supply of efficient machines. It was this neglect of seaplanes in the past which was responsible for the failure to keep pace with some other countries in the organising of services overseas, and while the navy is developing this type of machine for purposes of national defence the Air Ministry is preparing to bring out large commercial seaplanes which will allow of better services being carried out with South America and elsewhere.

The Moselle Canal.

The proposal to canalise the river Moselle was first made more than sixty years ago, but it is only recently that it has been possible to put the work in hand with the aid of German reparations, for which purpose orders have just been placed with two German companies. The canalised portion of the river will be between Metz and Thionville, a distance of a little more than 18 miles. It will provide for the navigation of barges of 350 tons, but the locks will be made large enough to permit of a widening of the canal later on to allow of the passage of boats of 1200 tons, if necessary. There will be five ports in all, including those at the termini. The new canal will be of considerable importance for the transport of metallurgical products in a territory that supplies nearly 40 per cent. of the total French production.

Water Sterilisation.

At the Académie des Sciences a communication was presented from M. G. Lakowsky upon the results of some experiments carried out to show the sterilising effect of certain metals in contact with water. It had long been known, he said, that some metals, like silver, destroyed microbes, and that confirmed his own theory of what he called "biological oscillating circuits." Some silver tubes wound in a spiral to increase the surface were placed in water containing different microbes, and in twenty-four hours the water was completely sterilised. It is said that all metals that do not rust, give the same result.

Fuel.

The policy of developing the home fuel supplies in order to restrict, as much as possible, the importation of coal is being carried out systematically, to the extent that, in 1928, the production of coal was more than 65 per cent. of the total consumption. From the point of view of national economy, the idea is to develop the production of coke which has grown considerably of late years, and efforts are made to encourage the use of coke for domestic heating instead of foreign anthracite, which it is hoped, in time, to eliminate almost entirely. It is claimed that the extension of the coke-making industry has already resulted in an economy for the country of more than a million and a-half tons of coal a year. On the other hand, the importation of coal for coking is regarded as a factor in national economy, since it is a raw material upon which labour is expended in the country. A great deal was expected from the production of alcohol and motor fuels by synthetical processes, but while giving promising results, the processes do not appear to have reached a commercial stage.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

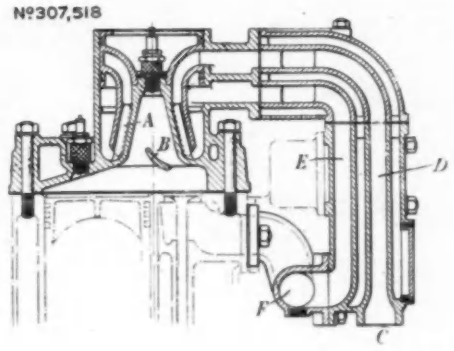
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

307,518. October 14th, 1927.—VAPORISERS, G. W. Watson, 50, Pall Mall, London, S.W. 1; and R. N. Martineau, Bolney House, Innesmore-gardens, London, S.W. 7.

This vaporiser is intended for use with heavy oil that is not easily vaporised. It comprises a conical chamber A in the cylinder head, which is preferably excentric to the cylinder bore.

Nº307,518



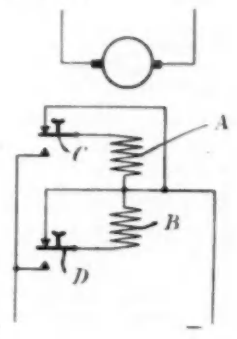
A baffle B directs the incoming mixture up into this conical recess. The incoming spray of fuel oil arriving at the inlet branch C passes through the pipe D, which is jacketed with exhaust gas, into the space which surrounds the conical recess. This part is ribbed to increase the heating effect. The gas then goes by the passage E to the manifold F and thence to the cylinders.—*March 14th*, 1929.

DYNAMOS AND MOTORS.

292,537. June 19th, 1928.—CIRCUIT CONNECTION FOR DIRECT-CURRENT ELECTRIC MACHINES WITH TWO SHUNT WINDINGS, *Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.*

For the purpose of obtaining simple circuits for changing the polarity of direct-current generators or for altering the sense of rotation of direct-current motors, two shunt windings in opposition to one another are often employed. If they are directly switched in and out it is customary to use resistances in parallel to the windings for the purpose of avoiding excessive voltages during the switching operation. These minimise the sparking on the switch, but load the latter with a current which increases the more it is endeavoured to reduce the excess voltage during the switching-off processes. It is especially deleterious in the case of the push button switches, which do not operate instantaneously, such as are often used for small outputs, and especially when the switching operations occur very frequently. According to this invention these disadvantages are avoided. If, for instance, the shunt winding A is switched in by depressing the

Nº 292,537



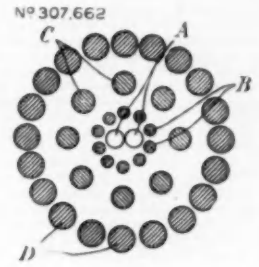
push button C then, when switching off, the shunt winding B, which is short circuited by the back contact of the push button D, acts as a damping winding and prevents the generation of any excessive voltage and consequently, of arcing. The same holds good when the winding B is switched in and out again by means of the push button D, as the winding A, then short circuited by the back contact of the push button C, acts as a damping winding. By reason of this connection the push buttons only carry the exciting current without having to carry any additional current such as would be called into existence by resistances in parallel. Should the two push buttons C and D be depressed simultaneously, no excessive voltage is generated as the effects of the windings A and B neutralise each other and no magnetic field is built up. Should, however, the push button C be switched off a little before the push button D, then a magnetic field due to the winding B would gradually be built up, but at the same time the winding A would be short circuited through the back contact of the switch C so that on subsequently switching off the switch D there would again be no excessive voltage present.—*March 14th*, 1929.

TELEGRAPHS AND TELEPHONES.

307,662. May 22nd, 1928.—IMPROVEMENTS IN OR RELATING TO CABLES, *Francesco Kalin, of 1, Bastioni Genavo, Milan, Italy; and Khusroo Dorab Vacha, of 59, Mark-lane, London, E.C. 3.*

This invention relates to armoured cables, and the object is to provide an improved armoured cable for divers and submarine vessels, such as diving bells. The invention consists essentially in enclosing one or more air tubes together with electric signalling and power conductors within a protective sheath which also serves to take the pull for lifting and lowering the diver or submarine vessel. The cable comprises a pair of air lines A which are preferably made of flexible metal tubing; a group of insulated electric conductors B for signalling and similar purposes surrounding the tubes A, a group of insulated electric power conductors C surrounding the conductors B, and an outer sheath or armouring composed of stout steel wires D. The conductors B and C are spaced by means of insulating material protected

Nº 307,662



from the action of the water, and the tubes A and conductors B and C may be twisted in the usual manner. The wires D are in close contact and are twisted in the usual manner so as to form a protective sheath and also to take a heavy pull so that the cable may be used for lifting and lowering a diver or submarine vessel. By these means all the connections necessary between a diver or submarine vessel and the mother ship or other base are comprised in the one cable so that the air tubes and electric conductors are adequately protected and all risk of entanglement of lines and cables with one another is avoided.—*March 14th*, 1929.

MACHINE TOOLS AND SHOP APPLIANCES.

307,689. August 16th, 1928.—THE ROLLING OF METAL DISC WHEELS, The Dunlop Rubber Company, Ltd., 32, Osnaburgh-street, London, N.W. 1.

This invention is concerned with the rolling of tapered section discs, such as those used for vehicle wheels, from a plain blank. It is explained that there is a tendency with ordinary rolling processes for the edge of the rolled piece to become wavy, but

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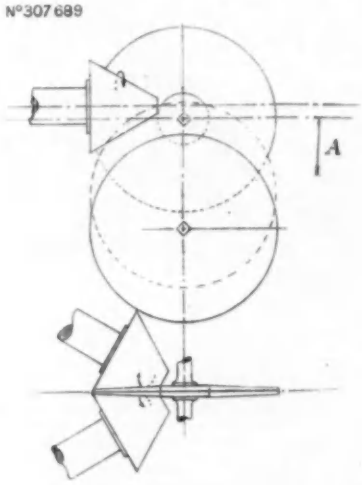

the inventors obviate this trouble. The blank is rolled between two conical rolls, as shown, and is fed upwards between them in the direction of the arrow A. The essential feature of the invention is that the feed should be stopped before the centre of the disc coincides with the axes of the rolls, as indicated at the end of the arrow. At this point the disc is then "shared" (? sheared) by rotation between a pair of rotatable circular knives.—*March 14th*, 1929.

307,648. April 13th, 1928.—APPARATUS FOR ELECTRIC RESISTANCE WELDING, James Harvey Gravell, of 338, Harrison-avenue, Elkins Park, Pennsylvania, U.S.A.

This invention relates to that type of welding wherein the heat

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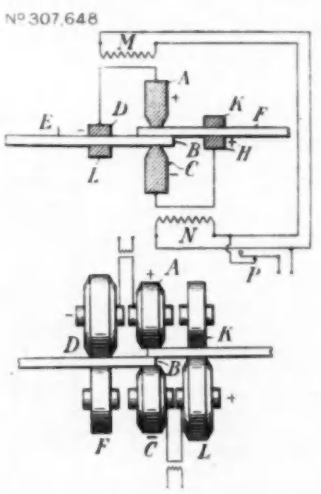


is developed directly in the work to be welded by the resistance of the work to the passage of an electric current. The invention is especially useful in connection with electric resistance welding by methods and apparatus in which pointed electrodes, buttons, rollers, &c., are employed for localising the welding.

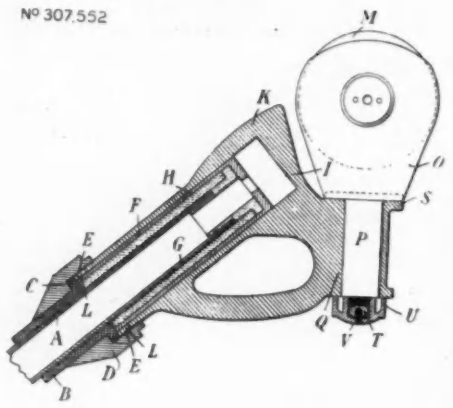
A indicates one welding electrode and C the opposite electrode. B indicates the point of application of the currents. The plates to be welded are indicated at E and F. D indicates a contact electrode or terminal for one welding current and H a similar contact electrode for the other welding current. The electrodes D and H are applied respectively to the elements E F, whilst K and L are rests designed to support the work against pressure applied to the contacting electrodes D H for the purpose of making good electrical contact with the work. Transformers for the two welding currents are indicated at M N respectively, while a switch P controls the application of the welding current. The current flowing from one welding electrode A, although passing the joint to be welded, does not enter the opposite welding terminal C, but completes the circuit by means of the platen contact electrode D. This is also true of the circuit H B C. Although these circuits coalesce at the joint B to be welded, they do not cross, each independent circuit remaining intact and returning to the point of origin, which is the transformer M and the transformer N respectively. The electrodes A and C constitute the jaws of a welding vice between which the parts to be welded are placed. The contacting electrodes D and H may be made to cover a relatively large area, so that practically no heating effect is produced where they contact with the work. Moreover, the contact electrodes D and H, being opposed by anvils H and L, may exert considerable pressure on the metal of the work. In other words, a contact electrode and an anvil may constitute an auxiliary vice for holding the work. In the lower illustration is shown an apparatus applying the invention to seam welding where the electrodes and anvils take the form of rolls.—*March 14th*, 1929.

TRAMWAYS AND RAILWAYS.

307,552. December 14th, 1927.—Improvements in Electric Trolley Heads, Albert Avtsine, of Barlow's Croft, Chapel-street, Salford, Manchester.

This invention has for its object to provide improved means for securing an electric trolley head upon the trolley arm so as to prevent its accidental detachment and also the access of rain to the trolley arm or the contact sleeve. The end of the trolley arm A is externally screw threaded to receive the internally threaded vulcanised fibre sleeve B. A flange C is formed on one end of the latter and is engaged by a collar D which is tapered internally and screw threaded at E so that it can be screwed upon the end of the cylindrical part of the trolley head K to draw and lock the trolley arm and head firmly together. The part of the trolley head upon which the collar D threads may be slitted as at L for a short distance and may also be tapered. The length of the slits L must not be greater than can be effectively covered by the collar D when it is screwed

No 307,552



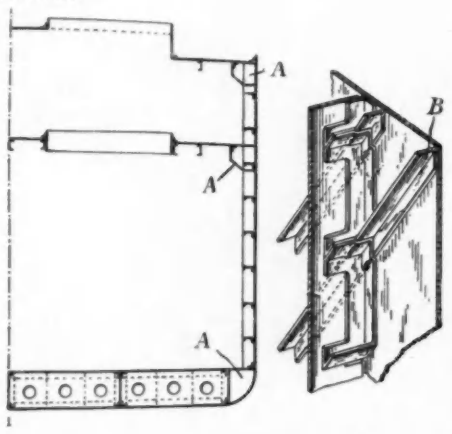
tightly home, so that no water can gain access to the slits. The outside of the collar D and adjacent parts may be covered with insulating tape, if desired. The end of the trolley arm A extends, as shown at G, beyond the sleeve H and is surrounded by a rubber sleeve F within the contact sleeve H, which is a good fit within the hollow interior I of the trolley head K. The details of the contact sleeve and of its connection electrically to the trolley arm form no part of the invention, but may be of any usual or suitable character. The trolley wheel M is carried within the carrier O, which is capable of a swivelling movement in the trolley head by means of the bolt P on the carrier, which can turn within a bearing Q in the trolley head. A nut U, which also forms an oil cup, screws on to the threaded lower end T of the bolt P and serves to hold the wheel carrier in position against the flange S upon the trolley head. A set screw V locks the combined oil cup and nut U upon the bolt P. It will be seen that a firm and rigid connection of the trolley arm and trolley head sleeve, which is moisture-proof, is provided.—*March 14th*, 1929.

SHIPS AND BOATS.

307,691. August 28th, 1928.—Hull Construction, H. E. J. Camps, 15, Bury-street, London, E.C. 3.

The framing of this inventor's ship is arranged diagonally

No 307,691



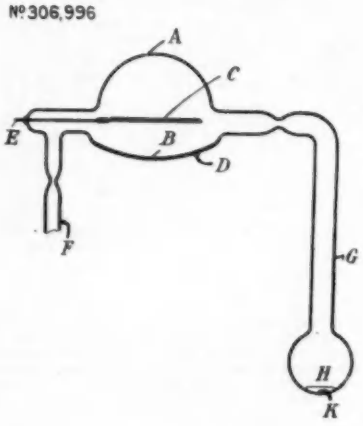
to the keel line and in this way, he claims, an improvement in strength, weight for weight, is obtained. There are three longitudinal girders A A A in the hull and between them there are arranged diagonal ribs as shown at B. This second sketch also shows one means of passing the ribs through a bulkhead. To avoid difficulties at the extreme ends of the hull structure, it is explained that the diagonal frames and the longitudinal girders do not extend beyond a certain point, the fore peak and after peak being of ordinary construction.—*March 14th*, 1929.

MISCELLANEOUS.

306,996.—December 1st, 1927.—Photo-electric Cells. The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C. 2, and Norman Robert Campbell, of Research Laboratories of the General Electric Company, Ltd., Wembley, Middlesex.

One method of making photo-electric cells according to the invention is shown in the drawing. The glass vessel A contains the electrodes B and C connected to the exterior by the leads D and E respectively. The electrode B is a layer of silver deposited chemically on the bottom of the cell, and the electrode C a nickel gauze. The cell is connected to an exhaust pump through the tube F and through the tube G to a vessel H containing a little potassium K. After the cell has been baked and exhausted and cooled, potassium is introduced by heating the tube G and vessel H. The tube G is then sealed off. The potassium is deposited on the electrode B by heating the remainder of the cell while the part B is cooled. When the whole vessel is cooled, the electrode B is heated gently by a flame, whilst a window is preserved at the top of the cell also by heating. A stage is reached at which the visible layer of potassium on the part B disappears rapidly. As soon as it has gone, hydrogen

No 306,996

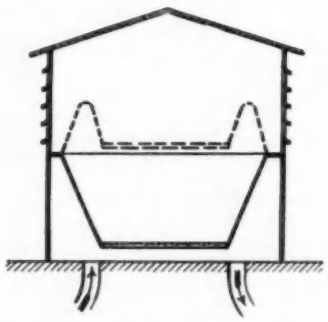


is introduced at a pressure of about 1 mm., and the whole cell allowed to cool. The presence of the hydrogen prevents further diffusion of the potassium. When the cell is cool an electric discharge carrying a few milliampères is passed with the part B as cathode and the part C as anode for a period, to be determined by trial, of the order of one minute. The cathode is then found to be much more sensitive to the red rays than a cathode of potassium prepared in the ordinary manner, and more sensitive than a cathode of caesium so prepared. The cell may be then completed in the usual manner. This process will give regularly a considerable red sensitivity; but the results are somewhat variable and the precise conditions that determine the best results are not easy to ascertain. It appears that the ultimate red sensitivity is determined largely by the initial condition of the silvered coating, and probably with an oxygen-containing film on its surface. Thus, procedures that tend to remove oxygen very completely should be avoided, and it may even be desirable to admit oxygen just before the potassium is introduced or even during its introduction.—*March 1st*, 1929.

307,179. February 8th, 1928.—Gasholders, R. W. Broadhead, Bindloss Chambers, 4, Chapel Walks, Manchester.

The inventor avoids the use of a telescopic joint in his gasholder by inserting a flexible diaphragm half-way up its height.

No 307,179



He does not state the material of which it is made. In the centre of the diaphragm there is a heavy disc to provide the necessary pressure. Alternatively, the load may be provided by compressed air above the diaphragm.—*March 7th*, 1929.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Institution of Electrical Engineers: Scottish Centre.—In the Hall of the Technical College, Bell-street, Dundee, "Load Levelling Relays and their Application in connection with Future Metering Problems," by Mr. W. Holmes. 7.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse. "English Civilisation from Alfred to Harold, 900–1066." 9 p.m.

Physical Society.—At the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. 7. A discussion on "The Teaching of Geometrical Optics." 5 p.m. Editing Committee meeting, 3.30 p.m.; Council meeting, 4 p.m. Tea will be served at 4.45 p.m.

MONDAY, APRIL 29TH.

Institution of Automobile Engineers: Scottish Centre.—Royal Technical College, Glasgow. "Brakes," by Mr. W. P. Kirkwood. 7.30 p.m.

TUESDAY, APRIL 30TH.

Illuminating Engineering Society.—In the Lecture Theatre of Holophane, Ltd., Elverton-street, Westminster, S.W. 1. "Some Further Properties of Glass and their Application in Illuminating Engineering," by Dr. S. English. A demonstration of various novel applications of coloured light will be given by Mr. R. Gillespie Williams. 6.30 p.m.

WEDNESDAY, MAY 1ST.

Institution of Automobile Engineers.—Joint meeting of the Birmingham and Coventry Graduates. Queen's Hotel, Birmingham. "High-speed Diesel Engines," by Mr. H. R. Ricardo. 7.30 p.m.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, London, W.C. 2. Wireless Section meeting. The following paper will be read and discussed, "A Portable Radio Intensity Measuring Apparatus for High Frequencies," by Dr. J. Hollingworth, M.A., and Mr. R. Naismith. 6 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, London, W. 1. Annual meeting. 5 p.m.

THURSDAY, MAY 2ND.

Royal Aeronautical Society.—7, Albemarle-street, Piccadilly, London, W. 1. The lecture by Captain Sinclair on "Wireless for Civil Aviation" arranged for this date has been postponed. There will be no lecture before the Society on this date.

THURSDAY AND FRIDAY, MAY 2ND AND 3RD.

Iron and Steel Institute.—At the Institution of Civil Engineers, Great George-street, Westminster. Annual meeting. For programme see page 155, February 8th, 1929.

FRIDAY, MAY 3RD.

Institution of Mechanical Engineers.—Storey's-gate, St. James's Park, London, S.W. 1. Informal meeting. "London's Water," introduced by Mr. Henry Berry. 7 p.m.

Joint Meeting of the Institutions of Automobile Engineers and Production Engineers.—At the Royal Society of Arts, John-street, Adelphi, W.C. 2. "The Production and Application of Ground Gears," by Mr. H. F. L. Orcutt, illustrated by cinematograph films showing gear grinding methods. 7.45 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "The Garden Tulip," by Sir Daniel Hall, F.R.S. 9 p.m.

SATURDAY, MAY 4TH.

Institution of Municipal and County Engineers.—Eastern District meeting at Red Lion Hotel, Cromer. 1 p.m.

Institution of Municipal and County Engineers.—South-Eastern District meeting at Croydon and Purley. Assemble at the Main Entrance to the Aerodrome Hotel. Discussion, "Town Planning and Municipal Air Ports," by Mr. Gilbert A. Ballard. 2.15 p.m.

MONDAY, MAY 6TH.

Railway Club.—57, Fetter-lane, London, E.C. 4. "The London Extension of the Great Central Railway: A Thirty Years' Survey," by Mr. D. S. Barrie. 7.30 p.m.

Surveyors' Institution.—12, Great George-street, Westminster, S.W. 1. "Rights in Underground Water," by Messrs. H. F. Bidder and W. Vaux-Graham. 8 p.m.

TUESDAY, MAY 7TH.

Institute of Marine Engineers.—In the Lecture Hall of the Institute, 85–88, The Minories, London, E. 1. Lecture, "Notes on the Lentz Standard Marine Engine as Fitted to Ships of the Koninklijke Paketvaart Maatschappy (Royal Packet Line), Amsterdam," by Mr. W. J. Muller. 6.30 p.m.

Institute of Metals.—Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. Nineteenth May Lecture, "Some Ideas About Metals," by Sir Oliver Lodge, F.R.S. 8 p.m.

WEDNESDAY, MAY 8TH.

Institute of Fuel.—Jointly with the Institution of Chemical Engineers, in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W. 1. "The Scope of the Chemical Engineer, with Special Reference to the Boiler-house and the Fuel Industries," by Dr. S. Wolff. 6 p.m.

THURSDAY, MAY 9TH.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, London, W.C. 2. Annual general meeting. 6 p.m. At the close of this meeting a special general meeting will be held.

FRIDAY, MAY 10TH.

Institution of Municipal and County Engineers.—Kenilworth Castle, Kenilworth. 10.45 a.m. Abbey Hotel, Kenilworth. Discussion on papers: "Stare Bridge," by Mr. D. H. Brown; "Kenilworth: Castle and Town," by Mr. Sholto Douglas. 5.30 p.m.

SATURDAY, MAY 11TH.

Institution of Municipal and County Engineers.—South Wales District meeting. Swansea. 11 a.m. Council Chamber, Guildhall, Swansea. Discussion on papers: "Some Road and Other Schemes at Swansea," by Mr. Robert Hudson; "Swansea Main Drainage Scheme and Flood Relief Schemes," by Mr. J. Hassall; "Llansamlet Sewage Pumping Scheme, Swansea," by Mr. M. E. Habershon. 3.15 p.m.

TUESDAY, MAY 14TH.

Royal Institute of British Architects.—Merchant Taylor's Hall, London. Annual dinner.

TUESDAY, MAY 14TH, TO OCTOBER.

North-East Coast Exhibition.—Newcastle-on-Tyne.

WEDNESDAY TO THURSDAY, MAY 15TH TO 23RD.

World Power Conference.—Sectional meeting, Barcelona. Conference on complete utilisation of water power resources. For programme see page 291, March 15th, 1929.

WEDNESDAY TO FRIDAY, MAY 22ND TO 24TH.

Institution of Water Engineers.—Birmingham. Summer general meeting. For programme see page 352, March 29th, 1929.

THURSDAY, MAY 23RD.

Faraday Society.—In the Rooms of the Chemical Society, Burlington House, Piccadilly, W. Annual general meeting, to read and discuss the Third (Experimental) Report to the Atmospheric Corrosion Research Committee (British Non-Ferrous Metals Research Association), presented by Mr. J. C. Hudson. 7.45 p.m.